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Carnegie-Mellon University
Software Engineering Institute

Exploring Hypermedia Information Services for Disseminating Software Engineering Information

William E. Hefley

February 1994

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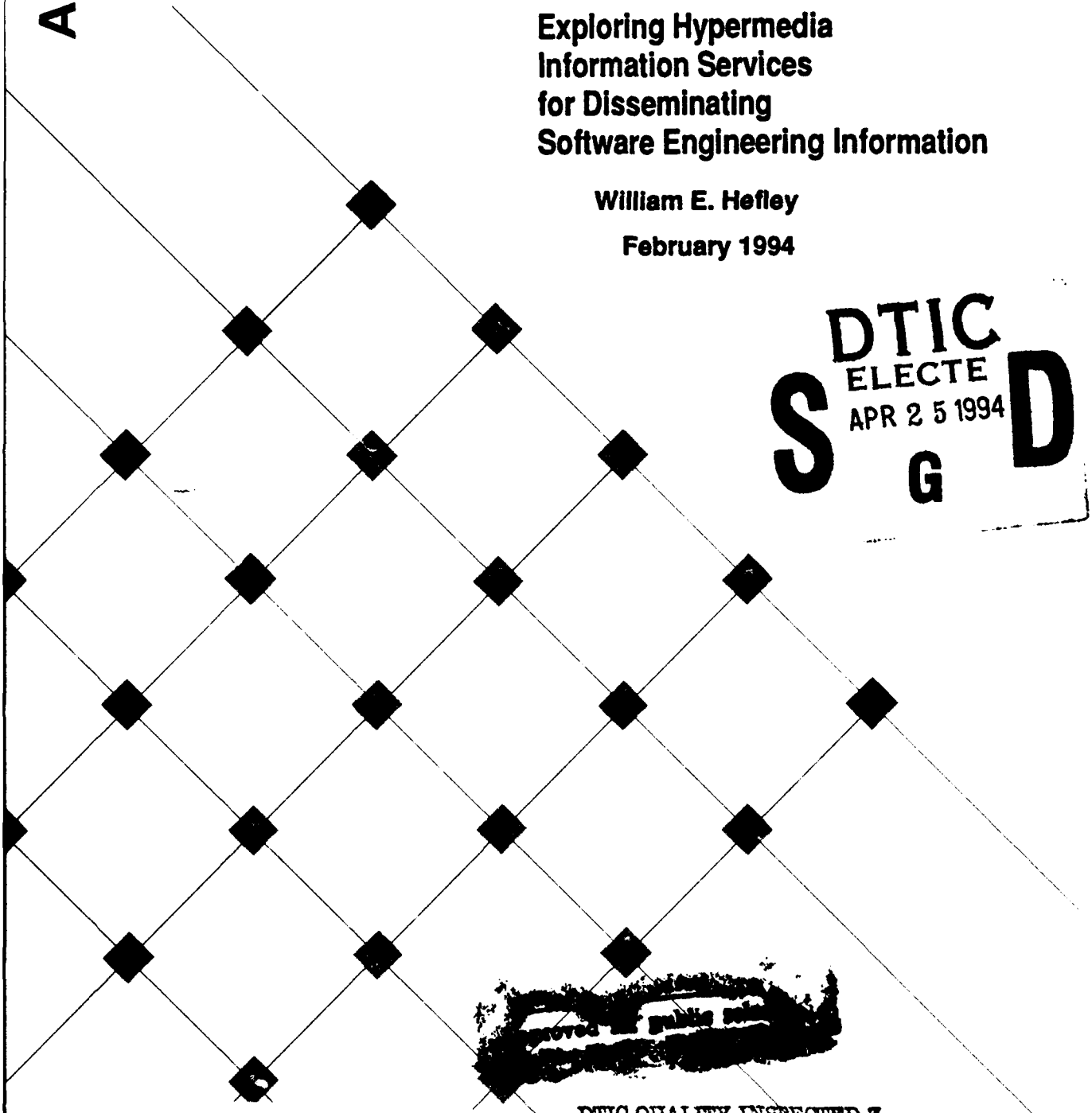

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Exploring Hypermedia Information Services for Disseminating Software Engineering Information

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William E. Hefley

Technology Transition Initiatives

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This report has been reviewed and is approved for publication.

FOR THE COMMANDER

Thomas R. Miller, Lt Col, USAF
SEI Joint Program Office

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Table of Contents

1 Introduction **1**
- 1.1 Background 1
- 1.2 Pilot Information Base Efforts 2
- 1.3 Scope of This Report 5

2 Concept of Operations **7**
- 2.1 Conceptual Definition of an Information Base 7
- 2.2 User Populations 7
- 2.3 Scenarios for Using the Information Base 8
  - 2.3.1 Program Manager 8
  - 2.3.2 Developer 9
  - 2.3.3 Receptor Group 9
  - 2.3.4 End User 10
  - 2.3.5 Technology Transfer Group 11
  - 2.3.6 Student 11
  - 2.3.7 Faculty 12
  - 2.3.8 Information Provider 12

3 Design Issues **15**
- 3.1 Selected Focus Area 15
- 3.2 Scope of Information Content 15
- 3.3 Design Principles 16
  - 3.3.1 Simplicity 17
  - 3.3.2 Structure for Finding Information Sources 17
  - 3.3.3 Flexibility 17
  - 3.3.4 Layering of Information 17
  - 3.3.5 Use of Existing Resources 17
- 3.4 Selected Pilot Technology 18

4 Pilot Information Content and Linkages **19**
- 4.1 Sources Reviewed 19
- 4.2 Information Structures 19
  - 4.2.1 Technology Area 21
  - 4.2.2 Project 22
  - 4.2.3 Technology Transfer Goals and Achievements 22
  - 4.2.4 Organization 23
  - 4.2.5 Sponsors 24
  - 4.2.6 Researcher 24
  - 4.2.7 Products 25

5 Pilot Information Base 27
5.1 Pilot Technology Approach 27
5.2 Pilot Focus Area 29
5.3 Pilot Implementation 30
5.3.1 Home Page 30
5.3.2 ARPA SISTO Software Efforts 32
5.3.3 Software Engineering Institute 38
5.3.4 Software Engineering Topics 41

6 Lessons Learned 45
6.1 WWW Technology 45
6.2 Information Content, Structure, and Access 45
6.3 Defining a Development Process 46

7 Follow-On Plan 49

Acknowledgments 51

References 53

Appendix A Sample HTML Templates 57

List of Figures

Figure 1:	Accesses to the Pilot System	5
Figure 2a:	Information Structure Model	20
Figure 2b:	Information Structure Model	21
Figure 3:	Growth of Internet Services: 1991-1993	28
Figure 4:	Home Page	31
Figure 5:	Initial Set of Choices	32
Figure 6:	ARPA Software Engineering Strategic Plan	33
Figure 7:	Software Engineering Environments	34
Figure 8a:	The Arcadia Project	35
Figure 8b:	The Arcadia Project	36
Figure 8c:	The Arcadia Project	37
Figure 9:	SEI CASE Environments Project	38
Figure 10:	SEI Home Page	39
Figure 11:	Results of a Search of the Annotated Catalog for the Term "environments"	40
Figure 12:	Software Engineering Topics	41
Figure 13a:	Topic Page for Software Engineering Environments	42
Figure 13b:	Topic Page for Software Engineering Environments	43

List of Tables

Table 1: Critical Indicators of Success for the SEI Pilot Effort 3
Table 2: Technology Area Information Structure 21
Table 3: Project Information Structure 22
Table 4: Technology Transfer Goals and Achievements Information Structure 23
Table 5: Organization Information Structure 23
Table 6: Sponsors Information Structure 24
Table 7: Researchers Information Structure 25
Table 8: Products Information Structure 25

Exploring Hypermedia Information Services for Disseminating Software Engineering Information

Abstract: This report describes the accomplishments of a pilot hypermedia information service embodying the conceptual definition of a pilot information base developed by the Software Engineering Institute (SEI) in support of the Advanced Research Projects Agency (ARPA) Software and Intelligent Systems Technology Office (SISTO). This pilot effort was conducted in support of the Technology Cost-Benefit Analysis tasks within TO&P 2-151, Software Engineering Technology Transition for Director, Defense Research and Engineering (DDR&E) and ARPA. This report also describes the intended uses and user populations of the proposed information base, design issues that influenced the structure and contents of the information base, a proposed information model consisting of information content and linkages, the pilot information base including the technology selected for the initial pilot effort and the pilot capability, lessons learned from the pilot effort, and future plans relating to the information base efforts. Key to these pilot efforts was the development of a set of proposed information structures for an information base on software engineering. These hypermedia-based information structures can be presented across the Internet and displayed on local workstations using client/server technologies, such as World-Wide Web (WWW) and NCSA Mosaic (produced by the National Center for Supercomputing Applications).

This work to date has accomplished four goals. First, the objectives of the pilot effort have been met. An information base containing software engineering information that provides value to ARPA program managers has been demonstrated, and a work plan has been generated to expand from the pilot to an operational system. Second, the SEI has demonstrated a capability for effectively using the WWW, which is certain to be a critical part of the information highway for years to come. Third, techniques to enhance developers' productivity have been identified and demonstrated. Preparation of online information can be aided by templates. Delivery of online information can be enhanced through study of actual users' navigational and usage patterns. Fourth, the SEI has established a "magnetic platform" as the facilities demonstrable at the SEI can be used as a starting point for developing new technology transition capabilities.

1 Introduction

1.1 Background

A need was recently identified to help explain, motivate, and track the various technologies being developed for or of interest to the Advanced Research Projects Agency (ARPA) Software and Intelligent Systems Technology Office (SISTO) for a variety of purposes and audiences. Key elements of the information-base concept being discussed were what information should be contained in such an information base, how the information could be used, how the information base could be accessed, and what tools would be appropriate for constructing the information-base capability.

Why collect this information? Online access to research and development information, coupled with efficient mechanisms for information browsing, retrieval, and subsetting of information for specific purposes, could be used for several purposes. For example, analyses of return on investment, technology transition strategies and plans, reports of past successes and lessons learned, and briefings on the SISTO software program can be prepared using the information base as a source of information. The information base could be used to aid in the identification of capabilities, products, and impacts that would result from ARPA software engineering research past, present, and future. The information base on the SISTO-sponsored research could then be expanded to include other related research in order to derive technology roadmaps and to focus on potential redundancies and dependencies.

1.2 Pilot Information Base Efforts

The Software Engineering Institute (SEI) was tasked to assist in addressing the need presented in Section 1.1. This report documents the results of that task.[1]

The approach adopted for this task was to conduct a pilot effort that began in October 1993, and that was completed during January 1994. The pilot effort focused on a limited information base; developed information searching and linking requirements; defined user interfaces and approaches for typical, repeated activities; and served as a basis for demonstrations to elicit further information needs. Within the pilot effort, information describing a defined set of SISTO-sponsored research was completed and stored in a pilot system. These critical indicators of success and the results achieved during the pilot effort are shown in Table 1. We consider the primary accomplishments of this pilot effort to be:

1. The defined objectives of the pilot effort have been met. The feasibility of implementing an information base containing software engineering information and providing value to ARPA program managers has been demonstrated, and a work plan has been generated to expand the pilot to an operational system.
2. The SEI has demonstrated a capability for effectively using a rapidly growing technology, as the WWW is certain to be a critical part of the U.S. and international information highway for years to come.
3. Techniques to enhance the productivity of developers have been identified. Preparation of online information can be aided by templates and document search mechanisms. Study of actual users' navigational patterns can be used to improve the delivery of online information, especially in identifying needed capabilities and desirable information linkages for various classes of users.
4. The SEI has now established a "magnetic platform" that people can use to create greater end user capabilities.

---

1. This pilot effort was conducted in support of the Technology Cost-Benefit Analysis tasks within TO&P 2-151, Software Engineering Technology Transition for Director, Defense Research and Engineering (DDR&E) and ARPA.

Table 1: Critical Indicators of Success for the SEI Pilot Effort

Indicator of Success	Result
Conceptual definition of the pilot information base	See Section 2
Definition of the information structure of the pilot information base	See Section 4
Development of an initial technology capability to support the pilot information base	See Section 5.1
Selection of a technology area as the focus of the pilot information base efforts	See Section 5.2
Populating the information base with a small number of SISTO-sponsored research projects	See Section 5.3
Demonstration of the pilot information base	Seven formal demonstrations have occurred to date: • Council of Consortia Technology Transfer Tools Review Meeting - November 10, 1993 • ARPA/SISTO - January 25, 1994 • Asset Source for Software Engineering Technology (ASSET) - January 27, 1994 • SEI Reengineering Center - February 4, 1994 • ASSET - February 4, 1994 • SEI - February 4, 1994 • University of Colorado - February 21, 1994 One additional demonstration is planned: • DDR& E - March 1994

The plan for the pilot effort was to demonstrate a proof-of-concept capability for capturing and disseminating information regarding current and past SISTO-sponsored research. The purpose of the pilot effort and the analysis that followed was to document the process and factor in lessons learned, yielding a more effective process as the effort expanded and automation increased.

During this pilot effort, the SEI completed:

- a conceptual definition of an information base on software engineering (Section 2.1)
- a set of usage scenarios (Section 2.3)
- an information model of the data and linkages (Section 4)
- a pilot information base (Section 5)

The SEI developed a conceptual definition of an information base on software engineering compatible with a hypermedia-based, Internet-accessible information delivery mechanism. That definition, presented in this report, describes possible concepts of use and potential user populations. Story formats are used to communicate scenarios involving real people and organizations faced with technological challenges and current technological solutions.

The initial pilot effort was a largely manual activity involving a small, defined amount of content information. Criteria were defined to guide the selection of the initial content area. "Software engineering environments" was the area of ARPA interest chosen as the focus of the pilot efforts.

To support this pilot effort, the SEI implemented a demonstration system. This demonstration system serves not only to explore possible mechanisms to support this pilot effort, as well as an eventual ARPA SISTO information base, but also serves as a means of soliciting valuable feedback from potential users. The selected pilot technology uses a widely available, hypermedia-based, Internet-accessible information delivery mechanism.

Publicly released information about the SEI was used as test data to populate the initial demonstration system. A Computer Emergency Response Team (CERT) project page was used as an early test bed for developing hypertext links to information on this and other servers. This project page served as a linking point to a hypertext Frequently Asked Questions (FAQ) document, which was developed as a proof-of-concept effort by CERT. A complete set of CERT advisories was also incorporated into the demonstration system.

The demonstration system is currently available only from the SEI, CERT, and selected hosts at ARPA.

Although the pilot effort was a largely manual activity involving a small, defined amount of content information, the pilot information-base system successfully demonstrated a proof-of-concept capability for capturing and disseminating information regarding current and past SISTO-sponsored research using an Internet-accessible, hypertext information delivery mechanism. Although not publicly announced, the pilot server logged over 5,000 accesses, as shown in Figure 1. This is only a fraction of the accesses logged by more established WWW servers, but nonetheless a sizable number of accesses for a service that was not formally introduced and announced.

The pilot system and WWW technologies were demonstrated to the Council of Consortia Technology Transfer Tools Review Meeting, held at the Software Engineering Institute on November 10, 1993. That demonstration introduced those organizations in attendance to the potential of this technology.

Numerous informal demonstrations of the pilot information base have been made throughout this pilot effort. A briefing and demonstration were presented to the ARPA SISTO director, program managers, and staff at the SEI Washington office on January 25, 1994. Subsequent demonstrations have been given to various Asset Source for Software Engineering Technology (ASSET) managers and staff, the SEI Reengineering Center, the Arcadia Project at the University of Colorado, and numerous SEI staff. A future demonstration is scheduled for DDR&E personnel. Feedback from these demonstrations has been used to evaluate and enhance the pilot information base.

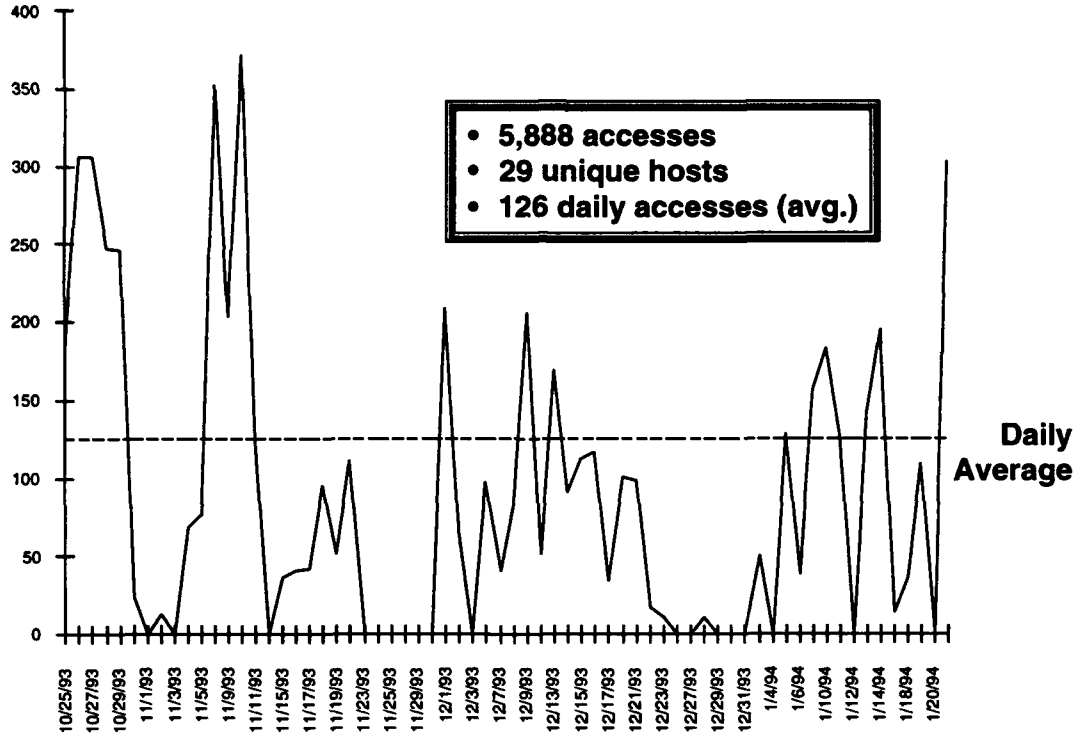

Figure 1: Accesses to the Pilot System

1.3 Scope of This Report

This report documents an exploratory use of network-accessible, hypermedia information services for disseminating software engineering information. This report describes:

- the accomplishments of the pilot effort
- the intended use of the proposed information base
- design issues that influenced the structure and contents of the proposed information base
- a proposed information model, consisting of information content and linkages
- the pilot information base, including the technology and focus area selected for the initial pilot effort and the implemented pilot capability
- lessons learned from the pilot effort
- future plans for expanding the pilot information base efforts to an operational system

2 Concept of Operations

2.1 Conceptual Definition of an Information Base

This section illustrates a conceptual definition of an information base on software engineering. This information base could be used to:

- Browse and navigate through related information using a simple point-and-click user interface.
- Support an orderly process for ensuring timely updates and additions to the information base.
- Potentially integrate with advancing technologies or with existing analysis and display packages.

The following sections describe possible concepts of use and potential use scenarios for a hypermedia-based information infrastructure, which could serve as this information base. A story format communicates scenarios involving people and organizations in the target audience and how they might use the information base.

In this information base, information would be organized and stored in a form to permit browsing and searching using varied criteria. It must present information that has been collected, sorted, and formatted for uses by various audiences.

The information base must be designed to support the needs of its intended audience and to provide easy access to information in the user's normal work environment. In extensive studies of information flows, Allen concluded that much of engineers' reading material is in the vicinity of their own desk [Allen 77]. Thus, the information base should be made accessible to the user populations as an integral part of their work environment.

2.2 User Populations

This section describes potential user populations and concepts of use of such a hypermedia-based information infrastructure. A story format communicates scenarios typifying people and organizations who are faced with technological challenges and are seeking potential approaches to meeting these challenges. The intended users include:

- program managers
- developer
- receptor group
- end user
- technology transfer group
- student
- faculty
- information provider

2.3 Scenarios for Using the Information Base

The following scenarios involve people and organizations in each of the roles described in Section 2.2, and how they might use or interact with an information base, like the one being proposed.

2.3.1 Program Manager

Program managers are often faced with technological challenges and seek current or evolving technological solutions to address various risk factors. Although this is true whether a manager is overseeing an advanced research and development program or is attempting to build a next-generation widget, this scenario focuses on a potential user who is responsible for encouraging and overseeing various high-technology advances.

Scenario

The program manager leans back in the chair and sighs. Yet again, the staff is being called upon to give an updated briefing later today showing the projects under their control, and some indication of key results, products, and where these efforts are leading to actual use—in civilian as well as military efforts. What is needed is a single information repository about their efforts, a ready source of up-to-date information that could be used to help formulate this briefing now, without having to contact each of the principal investigators and collate their inputs. Not that contacting them all was possible anyway on such short notice. Half of them are probably not available today because of class schedules or are away at a conference. By the time the inevitable game of phone tag would finish, today's briefing would be gathering dust in someone's file cabinet.

The program manager turns to the desktop computer and begins structuring thoughts for the briefing. Simple descriptive information about all of their projects is called up on the screen. The program manager selects several projects of interest for the briefing, and pertinent information on these projects is downloaded across the net to the local machine for use in creating the briefing materials and backup slides. Next, the program manager's focus turns to the products (the publications and prototypes) comprising the results of each of the projects. Again, based on the selected projects of interest, information about these products is displayed and selected to be downloaded for further editing. Since this was to be a short briefing focused on key results, the program manager sifts through the downloaded publications, saving those reports considered by the staff to be most seminal or having greatest impact for the intended audience. The briefing takes shape, as material retrieved from the information repository served as a starting point for editing a tailored presentation.

Identifying the civilian and military applications of the projects' results was all that remained. As a structured technology transition discipline was a part of each project, this information is already being captured and is available in the information base. The program manager scans the lists, creates an appropriate summary for the briefings, and downloads information about a few of the salient examples to use in creating backup slides.

The briefing is completed, queued to the printer, and there is even time for a quick lunch before running off to give the briefing.

2.3.2 Developer

Scenario

The principal investigator (PI) was pondering being asked questions like:

- What research are you currently doing?
- Who do you think the "customers" of that research are?
- How do you think they will use the results of your work?

Traditionally, there have been three sometimes conflicting customers to keep happy—the granting agencies, which tell what kinds of research have to be done to keep the lab running; the journal editors and reviewers, who tell what needs to do be done to get published; and the universities, which tell what must be done to keep a position or obtain tenure.

Increasingly of late, from both industrial and governmental sponsors, has come another pressure to make connections between the "20-year-out" academic research and the shorter term industry interests. The principal investigator turns to the terminal and begins scanning through the information base for projects that seem interesting—interesting because their technologies are similar to those being explored on the PI's project or because they faced the challenge of "connecting" or perhaps even because they resulted in an outstanding connection between academic research and industrial application.

The principal investigator finds one such project, dealing with the SEI Rate Monotonic Analysis (RMA) effort, and references to a number of papers and publications on this project. One of these publications seems especially relevant in describing a facilitated technology transfer approach. Wondering if this approach might be useful or insightful in understanding the technology maturation needs of the current project, the PI commands that the document be saved and queues it to a local printer for reading on the airplane later.

2.3.3 Receptor Group

Scenario

The issue of adding value is not a new one to the Software Engineering Process Group (SEPG) members at this large firm. The vision of investing in an SEPG is tied closely to understanding where the organization's capabilities lie, and rapidly improving these capabilities through focused improvements in the organization's people, processes, and technologies. In coordinating many of these internal activities, monitoring external research efforts, and benchmarking other firms, the SEPG acts as a receptor group spanning the gap between the organization's software engineering functions and the outside world.

This receptor group facilitates the mapping of generic improvements in technology, processes, tools, methods, or environments into the specific context of the organization. In doing so, they apply a structured continuous improvement process, including activities to:

- identify issues and needs within the context of the organization
- identify, track, and evaluate possible solutions to those issues and needs

The principal technology watcher in this SEPG regularly monitors ongoing efforts outside the organization. This monitoring is closely coupled with a defined process of ongoing evaluation of these advancing technologies, their maturation, and their potential use as pilot projects within the organization or in support of ongoing process improvement initiatives. This senior engineer has found a wealth of information about two key areas in the online information base: evolving software technologies and benchmarked "best practices."

By monitoring this repository on a regular basis, the SEPG can become aware of the technology developments and process improvements occurring elsewhere, and evaluate their applicability within the organization. They are able to find information and publications about new technologies and improved practices, and to bring this information into their own environment for evaluation.

2.3.4 End User

Managers who are responsible for software-intensive development efforts or those involved in improving the software practices of their organization often have special needs for finding information that provides insights into new technologies or practices that could be adopted by their organization. These information needs are similar to those of a receptor group, such as the SEPG described above, but are further constrained by:

- the time available to a single end user who is searching for information in addition to their other duties
- the reality of the information firehose–an "information overload" or "glut" of information from many sources
- a dearth of useful, focused information in accessible sources

Scenario

In spite of these constraints, an end user brings up a connection to the information base. The search today is motivated by a problem identified on the current project, and also by a growing awareness of certain risks identified on the new effort. By focusing the exploration and following the hypermedia links, the user is able to see the presentation made by another engineer at a recent conference that no one from their company was able to attend. The presentation pointed to some interesting uses of design technique described in a new text. In another open window on the terminal, the user requests this book from the company library.

2.3.5 Technology Transfer Group

Scenario

An engineer working at a research and development center is actively involved in planning the development, maturation, and transition of some exciting new technology advances. These advances are embodied in another analytical technique that can help software designers. But there are so many good techniques and common knowledge that do not seem to get picked up and put into widespread use that this engineer worries about whether their team's efforts will make it into everyday use. After all, this isn't the 70s, and there's no Yourdon or DeMarco on the team.

They turn to an information base to find examples of other technologies that are conceptually similar—analytical techniques to help designers—and efforts to gain widespread adoption of these techniques. Finding information about the Software Engineering Institute RMA technique leads them to explore SEI notions of technology maturation, and points them to various publications. Some of these publications describe the method and tools to support it, but others describe training and other publications; still others describe how technology maturation was applied to RMA. These examples and case studies will be very valuable in planning the introduction and dissemination of the team's new technique.

2.3.6 Student

Scenario

A masters' student in one of the growing number of graduate software engineering programs is starting to work on a paper. Information about a design technique is needed to help prepare a technique-focused paper for this semester's software design course. Each student is expected to prepare a report, integrating personal discoveries about the technique with computer software models illustrating the use of the technique, along with original descriptive text and hypertext background material.

It would be preferable if the technique could also be used in next semester's studio course, but that would take more work to understand the implications of using a technique instead of just regurgitating facts about it in a research report.

Using an online, network-accessible information base, the student begins searching through an index of recent technical reports looking for topics that might be appropriate. Once a few likely subjects are identified, and the reports retrieved, they go into the backpack to read at home tonight.

After reading through these technical reports, there may be one or two techniques that look interesting enough to experiment with and that might also be useful for the upcoming studio. The information base, coupled with existing network capabilities like file transfer protocol (FTP) and finger, give easy access to more information about the techniques and their developers. Having this access, plus the ability to download hypertext-formatted data from the servers (including the information base), provides a wealth of online research information to help prepare this report.

2.3.7 Faculty

Scenario

The young professor stretches, tired from reading student papers. The students had done a good job on their software design techniques papers for the design course. There were even some really interesting example cases that might make good teaching aids later. But there wasn't anything there about design techniques for aiding in integrating advanced user interface concepts like graphical user interfaces (GUIs) and intelligent agents into the software engineering methods and computer-aided software engineering (CASE) tools.

For the lab's newest project, they are going to try to address concerns about CASE in client/server environments. Some people are coming to the realization that it is hard to get from a given design into a GUI, let alone address the knowledge base development issues of building intelligent agents. At the moment, as far as they knew, there really are no engineering processes or methodologies that address the movement from requirements and concepts of operations to knowledge structures and then to screen layouts, and eventually to code.

The faculty are preparing a proposal in response to a recently-released request for proposals, but need additional information to bolster the sections of the proposal addressing the relevance of proposed efforts and related activities. Information from the students' reports would have helped, but there were no relevant student papers. And they had tapped out their own local bibliographies.

From the online information base, they locate background material about the request for proposal from the sponsor and identify some interesting topics that are related, and could help make their case. They are also able to confirm that other ongoing efforts are related, but are not addressing the procedural and methodological focus the lab feels should be present to later transition the resulting design concepts into use.

2.3.8 Information Provider

Scenario

As a broker of advances in software engineering, the institute provides information about a broad number of software-related topics. Having an information base accessible augments the information about the institute's own efforts being provided by their information services, and allows them to provide seamless linkages between the two.

The developers, researchers, SEPGs, and academics who turn to them for information are able to gain access to substantially more information than had been available previously in the hard copy, technical report days, and the institute is able to distribute it in a more timely, cost-effective fashion. Just a few years ago, the projections had been that, if they continued printing and mailing technical reports, the institute's entire budget would go to printing and mailing costs in just a few more years.

The technical reports are still in the information base, together with other things that were not archived or made widely available in the past. With a color workstation and NCSA Mosaic software being used for many briefings, the slides sets or proceedings of these meetings are often available to the net within just a few days of a meeting's end, increasing the reach and timeliness of the information that the institute can disseminate.

Also available is a growing repository of notices, announcements, and presentations from the various software process improvement network (SPIN) groups that are emerging as organizations strive to improve their capabilities. Best practices information is starting to appear in forms that organizations can use to help with their benchmarking and process improvement activities. Soon there will be additional material produced by the professional societies as they begin to use electronic dissemination to augment their paper-based print dissemination techniques.

The institute, while not producing all of this information, serves as a conduit for the software engineering community to find this information, reach it, and apply it.

3 Design Issues

3.1 Selected Focus Area

Although a single focus area was selected for the pilot effort[2] and ongoing projects in this area were given special emphasis in the information content and structure analyses, the intent was to define a structure that was not dependent on any special characteristics of a specific technology area.

3.2 Scope of Information Content

A number of questions arose in defining the appropriate information structure and content. These questions, and the design assumptions made in response to each, are:

- What is the appropriate scope of visibility for information contained in this information base?

  It has been assumed that this "information base" will be broadly available for use by a broad audience,[3] not just as an in-house tool for ARPA. Depending on the technology used for the final system, certain data within the information base could be segregated for visibility only by selected users, hosts, or Internet domains.

- Why should ARPA make this information about its projects available to others, as well as themselves?

  It has been noted in the transfer of software engineering innovations that joint internal and external communications approaches were useful, as materials obtained from sources external to the organization often had more impact than materials obtained through internal communications [Paulish 93]. It has also been noted that ARPA could benefit from increased sharing of information regarding its projects [Havelock 85].

- Are there certain data in the information structures that may not be disseminated widely?

  Certain information (see Section A.5) is derived in part from the data content of the ARPA Program Approval Document or a Defense Technical Information Center (DTIC) Work Unit Summary produced from the Department of Defense Research and Technology Work Unit Information System. However, the Work Unit Summaries that have been provided by DTIC to the SEI in response to requested searches are limited in their distribution to the U.S. government and its contractors only. It is not clear whether it is specific data items, a combination of data items, or the amalgamation of this data that limit the distribution of this information.

  These data may be candidates for further layering and access controls in the final information base.

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2. See Section 5.2 for more about this selection.

3. See Section 2.2 for an enumeration of the components of this target audience.

- At what point in technology maturation should an effort be included in the information base?

  Although Fowler's Advocate/Receptor model [Fowler 90] describes innovation diffusion in terms of producers, receptors, advocates, and consumers and the corresponding transactions between each, the information base is intended to reach a broad audience.[4] Each person or organization being reached may be at a different stage in these processes of transferring software engineering innovations with respect to a given innovation.

  Not only does each [Producer, Advocate, Receptor, Consumer] tuple exist at a unique state, but it has been observed that it is not useful to wait until a technology matures to start the adoption process, because the technology will mature during the process [Leon 93].

  Thus, to best meet the needs of the broadest audience, any effort, once started, should be included in the information base. By providing the largest possible repository of focused information, the information base can enhance the absorptive capacity [Cohen 90] of an organization to identify and assimilate external information.

- What efforts are candidates for inclusion? Is there a reason not to include projects (or pointers to projects) outside of ARPA-sponsored work?

  If the information base is to be useful to a broad audience, as well as ARPA staff, it could reasonably be expected to include information about or pointers to a variety of efforts in the technology areas of interest. This can help by providing the users with information, whether they be ARPA users desiring to keep abreast of new developments outside their program area [Havelock 85] or end users seeking information of use to them.

3.3 Design Principles

A number of design principles guided the definition of the information structures. These include:

- simplicity
- structure for finding information sources
- flexibility
- layering of information
- use of existing resources

These principles and their impact on the information structure are discussed below.

4. See Section 2.2 for an enumeration of the components of this target audience.

3.3.1 Simplicity

A simple set of standardized templates provides consistency for users of the information base. It also provides a common framework for data collection for those updating and maintaining the information base. Information content was defined in terms of easily understood concepts and free-form textual descriptions.

3.3.2 Structure for Finding Information Sources

As reported by [Erickson 91], it is important that an end-user framework of the information structure support a means of finding or locating information sources. The information structure should support "skimming" by the user seeking information, but should also provide an easy means of locating and using information resources. Search mechanisms to allow efficient location of information and subsetting of the information base can be coupled with the navigation features of hypermedia. This can provide end users with multiple access paths to various information sources and a structuring framework to support end users in finding information sources.

3.3.3 Flexibility

The use of the hypermedia information structures provides for flexibility (or extensibility) in the information presentation. Where additional information exists, or additional details are desired, it is possible to extend the defined templates by inserting links to additional units of information within existing or new information structures.

3.3.4 Layering of Information

A layered approach should be taken in supplying information to potential clients of a technology innovation [Paulish 93]. The proposed information structure described in Section 4 attempts to utilize such an approach.

Details about sponsors, their goals and project details, as well as detailed information about technology transition, are layered behind more salient information about the research projects themselves. Hypertext links allow navigation to see these additional layers of information. The information structures and their hypertext links are shown in Section 4.

3.3.5 Use of Existing Resources

Existing network-based resources can be used wherever possible within this information structure. As there are a number of existing information resources, a structure for identifying and linking to the information resources available within a technology area or an organization was included in the information structure.

Existing information resources (i.e., content sources) can be used wherever possible. In many cases, existing content can be converted for use, and may even lend itself to being hyperlinked with other content. In some cases, existing documents can be provided in their current formats.

3.4 Selected Pilot Technology

The technology approach selected for the pilot effort did not influence the information content, but is reflected in various ways in the information structure analyses, including:

- The hypertext capabilities of WWW allow information hiding or layering of data in the information structures.
- The formatting capabilities of the Hypertext Markup Language (HTML) can be used for online presentation and printed reports, as the browsers support saving or printing formatted text on the local platform.
- Specific search queries and traditional database-oriented searching capabilities need not be defined, as the client/server capabilities can support searching, as well as full wide area information servers (WAIS) indexing.

4 Pilot Information Content and Linkages

This section describes the initial set of data elements that will be captured in the information collection efforts for use in the pilot information base. The resulting information structure is proposed as a basis for further development of the information base.

4.1 Sources Reviewed

The following information sources were reviewed in preparing the proposed information structure and content definition:

- *Proceedings of the DARPA Software Technology Conference*, April 1992
- *Software Engineering Program Plan*, presented at the SEI Software Engineering Symposium, August 1993
- *Proceedings of the Sixteenth Advanced Research Projects Agency Systems and Technology Symposium*, June 1993
- *Software Engineering Institute Documents*, September 1993
- *SEI Program Plans: 1994-1998 (Draft)*, SEI-93-CDRL-402, July 1993
- DTIC Work Unit Summaries (produced by the DoD Research and Technology Work Unit Information System)
- *The First Collected Arcadia Papers*, 1993
- Arcadia Project Briefing, 1993
- software technology transfer workshops (including [IFIP 93, Przybylinski 87, IEEE 83] and the 1987 MCC/SEI/SPC workshop)

Additionally, an extensive review of existing WWW resources was undertaken to identify exemplary design cases. Existing resources in software engineering, computer science, and other disciplines were examined, as were resources used for many diverse information dissemination uses.

4.2 Information Structures

This section describes a set of proposed information structures, their contents, and their linkages to comprise an information base on software engineering. The information structures proposed during this pilot effort are hypermedia-based information structures that can be presented across the Internet and displayed on local workstations using WWW client/server technologies. The proposed information structure is depicted in Figures 2a and 2b.

Hypertext Markup Language (HTML) is the document encoding used by the WWW/Mosaic technology used for the pilot effort. For this reason, sample HTML templates for each of the proposed information structures can be found in Appendix A (Sample HTML Templates).

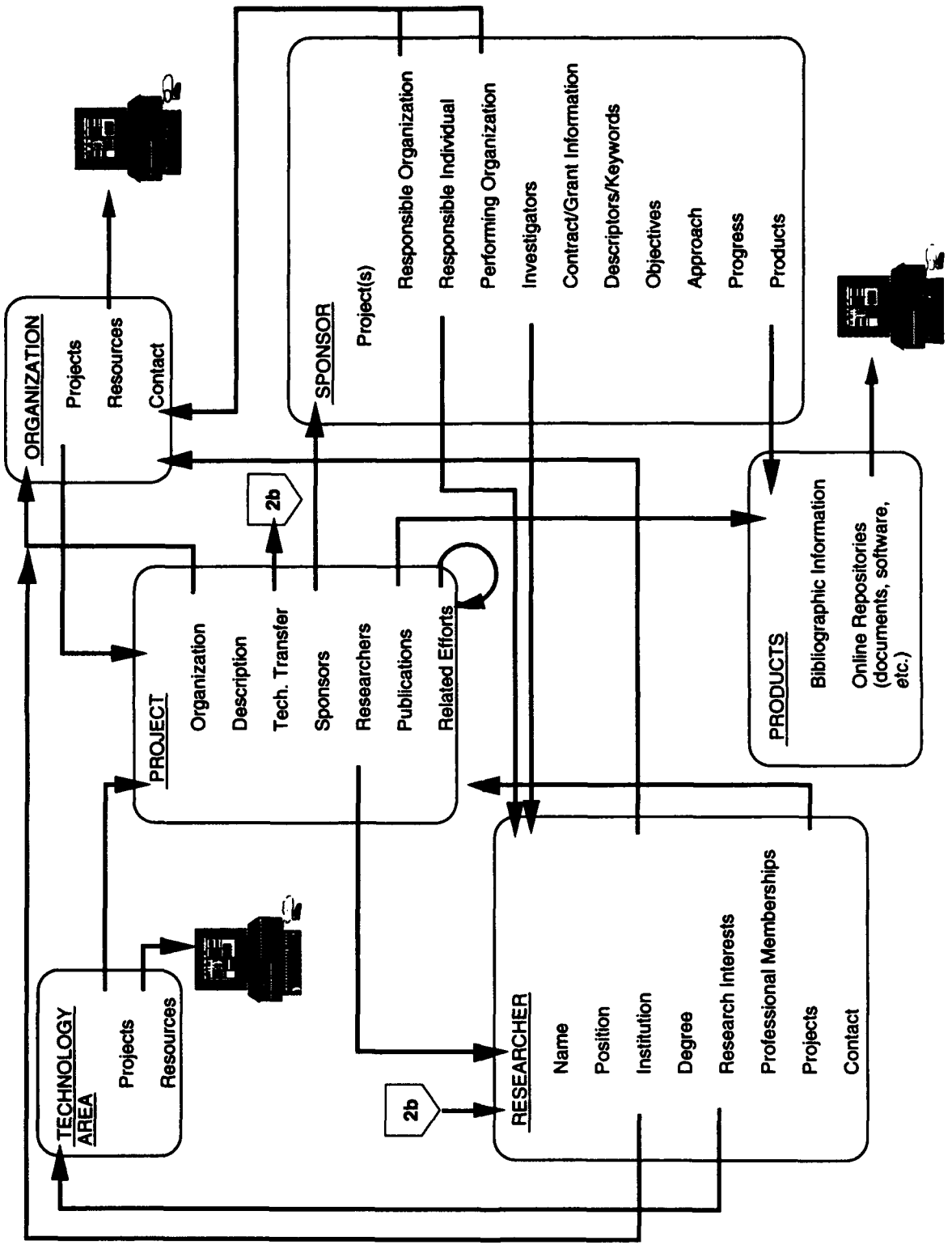

Figure 2a: Information Structure Model

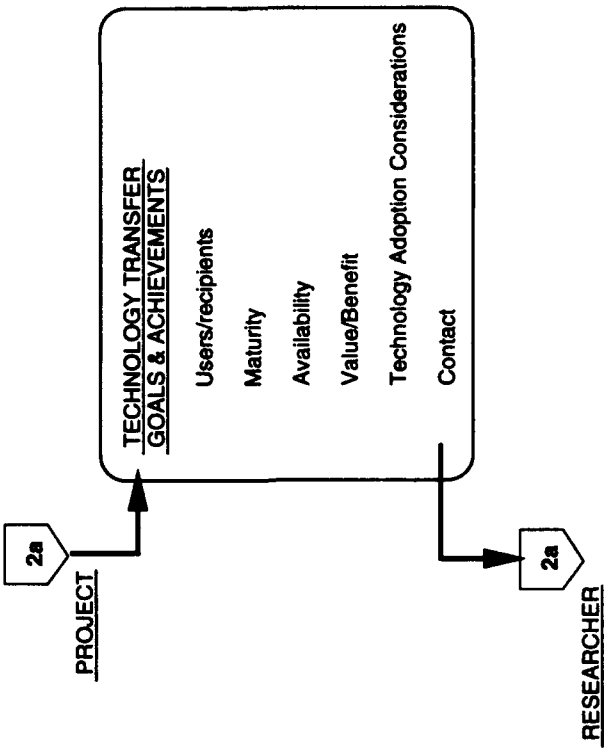

Figure 2b: Information Structure Model

4.2.1 Technology Area

The technology area (topic or area of interest) is one of the initial entry points into information structure. It serves as a structuring mechanism by collecting in a single information structure links to projects and resources in the area of technology.

Table 2 identifies the key contents and linkages of the technology area information structure.

Using presentation formatting or hypertext linkages, it is possible to further subdivide an area of interest into subtopics to aid the user in locating information.

Table 2: Technology Area Information Structure

Key Content Area	Linked	Linked to:
Projects	Yes	Specific projects
Resources	Yes	Known resources relevant to the technology area

4.2.2 Project

A key component of the proposed information structure is the project. Within the information base, the project is the key information structure. The project information structure contains information about the project and linkages to other information about:

- project technology transfer goals and achievements
- project sponsors
- researchers involved with the project
- publications and other "products" of the project
- other related projects

Table 3 identifies the key contents and linkages of the project information structure.

Table 3: Project Information Structure

Key Content Area	Linked	Linked to:
Organization	Yes	Performing organization
Description	No	
Technology Transfer Goals and Achievements	Yes	Layered information describing technology transfer aspects of this project
Sponsors	Yes	Sponsoring organization
Researchers	Yes	Specific researchers involved in the project
Publications	Yes	Information about publications, products, or other artifacts from the project
Related Efforts	Maybe	Other projects (if information about them is available or they support an information server)

4.2.3 Technology Transfer Goals and Achievements

An important component of the information base is the technology transfer goals and achievements information structure. It contains descriptive information about the intended uses of project efforts, and can serve to identify potential benefits and costs as well as technology transition topics that should be addressed. The information structure in Table 4 could be used to support analyses of return on investment, develop technology transition strategies and plans, prepare reports of past successes and lessons learned, and, perhaps most importantly inform end users in making judgments about the fit of this technology to their organizations.

Table 4: Technology Transfer Goals and Achievements Information Structure

Key Content Area	Linked	Linked to:
Users/Recipients	No	
Maturity	No	
Availability	No	
Value/Benefit	No	
Technology Adoption Considerations	No	
Contact	Maybe	Can be linked to a specific person

4.2.4 Organization

The organization information structure serves as another of the structuring mechanisms within the information base. It collects in a single information structure links to projects and resources within a specific organization. In cases where an organization is providing some Internet-accessible information service, the organization information structure can also point to this resource. Table 5 identifies the key contents and linkages of the organization information structure.

Table 5: Organization Information Structure

Key Content Area	Linked	Linked to:
Projects	Yes	Projects within the organization
Resources	Yes	Known resources provided by the organization (information server, FTP server, etc.)
Contact	No	

4.2.5 Sponsors

The sponsors information structure provides information from the perspective of a sponsor of research projects. Specific administrative information, such as key contacts, contract number, and internal keywords or descriptors are contained in this information structure. Publications, products, or other artifacts from the project can also be cataloged within this structure. Table 6 identifies the key contents and linkages of the sponsors information structure.

Table 6: Sponsors Information Structure

Key Content Area for Each Project	Linked	Linked to:
Responsible Organization	Yes	Sponsoring organization
Responsible Individual	Yes	Person
Performing Organization	Yes	Organization performing the project
Investigators	Yes	Specific researchers
Contract/Grant	No	
Descriptors/Keywords	Maybe	Some could be linked to technology areas
Objectives	No	
Approach	No	
Progress	No	
Products	Maybe	Information about publications, products, or other artifacts from the project

4.2.6 Researcher

The researcher (or person) information structure provides a framework for structuring common information identifying and describing the individual. It is in some respects analogous to the .plan files in UNIX™ environments. It also provides the potential for linking individuals to their organization(s), project(s), and areas of interest (technology areas). Table 7 identifies the key contents and linkages of the researchers information structure.

Table 7: Researchers Information Structure

Key Content Area	Linked	Linked to:
Name	No	
Position	No	
Institution	Yes	Organization
Degree	No	
Research Interests	Maybe	Technology areas (if extant)
Professional Memberships	No	
Projects	Yes	Project
Contact	No	

4.2.7 Products

The products information structure collates and presents information about publications, products, or other artifacts from the project. It can serve as a link to existing reports, manuals or bibliographies, or it can contain bibliographies or publications lists. It can also serve as a link to other online repositories containing documents, software, examples, or other artifacts from the project.

The products information structure is included in this description of the information base, as it is integral to disseminating information about the results of research projects. Table 8 identifies the key contents and linkages of the products information structure. Although represented in Figure 2a, no HTML template for the products information structure is contained in Appendix A because of the variability of types of information that could be presented in this structure.

Table 8: Products Information Structure

Key Content Area	Linked	Linked to:
Bibliographic Information	Maybe	
Online Repositories	Yes	Known resources (information server, FTP server, etc.)

5 Pilot Information Base

5.1 Pilot Technology Approach

Designing a heterogeneous information base that is readily and easily accessible by its intended users is potentially one of the most important aspects of this effort.

For these reasons, a networked means of information dissemination was selected to support the pilot effort. The WWW is an Internet-based global hypermedia information system [Berners-Lee 92a, Berners-Lee 92b]. This technology supports:

- user interaction with a diverse collection of information resources, including:
  - online presentation of text, graphics, and multimedia material
  - hypertext linkages between material
- centralized (or decentralized) information repositories
- searches, retrieval, and data manipulation
- access to information
  - across the Internet
  - from a number of key platforms (X Window System, Microsoft Windows, Macintosh)

With its first files on the network in August 1991, and widely introduced to the community in late 1991 [Berners-Lee 91], the WWW has been experiencing a steady growth. Figure 3 depicts the growth of five key end-user protocols across the NSFNET backbone throughout 1991, 1992, and 1993. According to these statistics, WWW went from the 964th largest service traversing the NSFNET backbone in January 1992 to the 10th largest service in December 1993.

There are a number of existing software programs that allow end-user access to WWW. Prominent among these is NCSA Mosaic.[5] NCSA Mosaic is a powerful and easy-to-use multi-platform program. It is an Internet-based global hypermedia browser client that allows discovery, retrieval, and display of documents and data from servers located across the Internet. NCSA distributes three versions of this program:

1. NCSA Mosaic for the X Window System
2. NCSA Mosaic for the Apple Macintosh
3. NCSA Mosaic for Microsoft Windows

This technology is gaining widespread notice [Markoff 93, Markoff 94, Tetzeli 94]. NCSA estimates that tens of thousands of copies of the PC and Macintosh Mosaic programs are in use, while NCSA Mosaic for the X Window System has a current estimated user base of 100,000.

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5. NCSA Mosaic is a product of the Software Development Group of the National Center for Supercomputing Applications at the University of Illinois at Urbana-Champaign.

NCSA Mosaic is distributed by NCSA without a fee for academic, research and internal business purposes only. NCSA licenses this software for commercial use when NCSA Mosaic is sold as a product, integrated into a product, or distributed to access a commercial product.

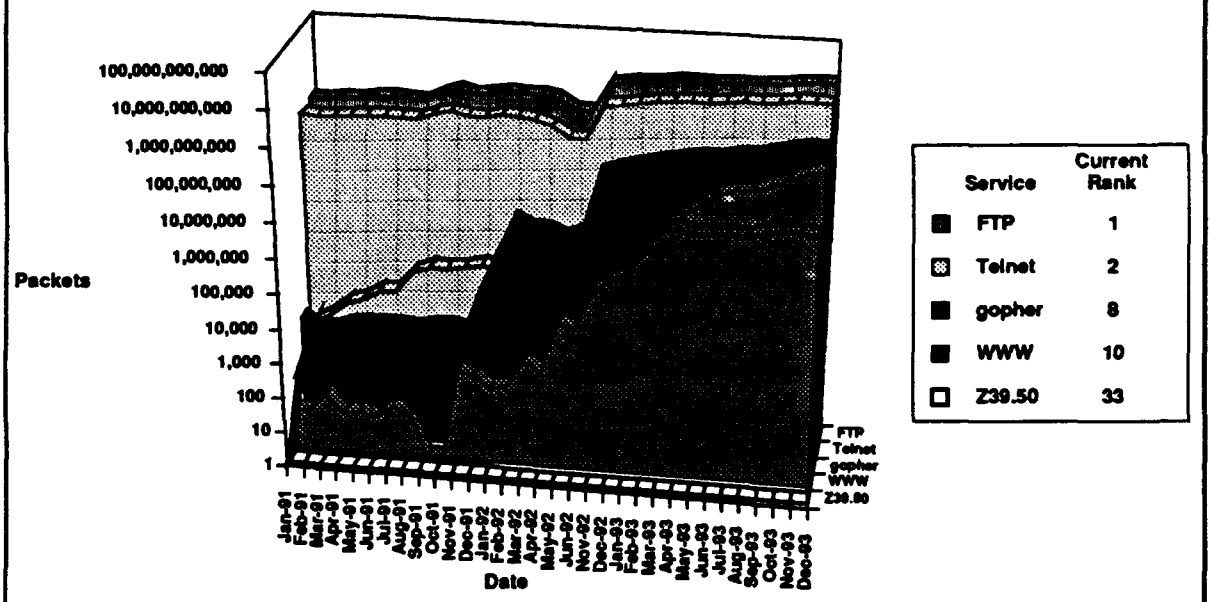

Figure 3: Growth of Internet Services: 1991-1993

NOTES:

1) Only traffic traversing the NSFNET backbone service is shown.

2) On September 2, 1991, a sampling method to collect statistics was begun. The traffic data shown are scaled as if all packets had been analyzed. Sampling should not affect the magnitude or the ordering of the majority of the data in the report, but omissions may occur for extremely low volume entities.

3) Only partial data are available for December 1991 and March through May 1992.

4) No data are available for the period July through October 1992.

SOURCE: `ftp://NIC.MERIT.EDU/nsfnet/statistics`

Using client/server technologies, the user executes a client browser program at the local platform to access any web server. Information providers establish hypermedia servers which make documents and information accessible to client browsers. The browsers can, in addition, access files by a variety of means, including local file access, FTP [Postel 85],

Gopher [McCahil 92], Network News Transport Protocol (NNTP) [Kantor 86], WAIS [Kahle 92], and an ever-increasing range of other methods. If the server has search capabilities, the browsers will permit searches of documents and databases. WWW uses one connection per search or retrieve operation between the client and a server [Berners-Lee 92b]. After each network operation, the client program then formats retrieved documents and status for presentation to the user.

WWW technologies were selected to support this pilot effort, and NCSA Mosaic has been used for our development and demonstrations. The widespread availability of multiple-platform, publicly distributed software overcomes many of the reasons why electronic media have not been used much for technology transfer applications [Havelock 87].

5.2 Pilot Focus Area

This section enumerates the criteria and identifies the technology area within SISTO-sponsored research projects that was selected as the focus of the initial pilot efforts.

Selection criteria were developed to guide the selection of a technology area as the focus of the initial pilot efforts. The following documents were reviewed in preparing these criteria:

- *Proceedings of the DARPA Software Technology Conference*, April 1992
- *Software Engineering Program Plan*, presented at the SEI Software Engineering Symposium, August 1993
- *Proceedings of the Sixteenth Advanced Research Projects Agency Systems and Technology Symposium*, June 1993
- *Software Engineering Institute Documents*, September 1993
- *SEI Program Plans: 1994-1998 (Draft)*, SEI-93-CDRL-402, July 1993

Candidate criteria for selecting the technology area focus for the pilot effort include:

1. General criteria
    a. The area should be important, and activities in the area should be perceived as potentially leading to high-leverage solutions.
2. ARPA-focused criteria
    a. The technology area should be supported by an ongoing program.
    b. The program should not be just starting (i.e., there should be a body of already completed work).
    c. The technology area/program should include a mix of industrial, academic, and military participants.
    d. The technology area/program should be applicable to multiple problem domains.

3. Desired SEI-focused criteria

    a. SEI is involved in this technology area.

    b. SEI plans to continue work in this area.

    c. SEI staff have published in this area to provide a ready pool of publication data for the demonstration project.

4. Desired staffing criteria

    a. Personnel developing the pilot capability have some prior knowledge of the technology area, its evolution, and related publications.

Based on these criteria, viable focus areas included domain-specific software architectures (DSSA) or software engineering environments (SEE).

In light of the criteria above and discussions with SEI and ARPA staff, the area selected as the focus of the pilot effort is the area of software engineering environments. In addition to the chosen technology area of software engineering environments, selected SEI data were embodied in the pilot system, both to complement the pilot data and as a means of testing pilot system capabilities.

Information was collected regarding software engineering environments, specifically the ARPA SISTO-sponsored Arcadia efforts and the SEI CASE Environments project. Additional SEI data were used as a test data set for testing pilot server capabilities and prototyping information formatting. As a by-product of testing the implemented server's capabilities, a comprehensive set of information about SEI programs, events, and publications was integrated into the pilot system.

5.3 Pilot Implementation

This section leads the reader through a brief guided tour of the pilot information base, as it was constructed and demonstrated. This is not a complete tour of all information contained in the pilot system, but provides an overview of the capabilities that have been constructed in the pilot system.

5.3.1 Home Page

Although the primary focus of the pilot effort was software engineering environments, information about the Software Engineering Institute and various software engineering topics was also included in the pilot system. Additionally, a set of links to other Internet-accessible resources was made available for convenient access by the users. These links provide convenient access to other information repositories or services.

The following figures show the initial home page encountered by a user of the pilot system (Figure 4), and the initial set of choices presented to this user on the home page (Figure 5).

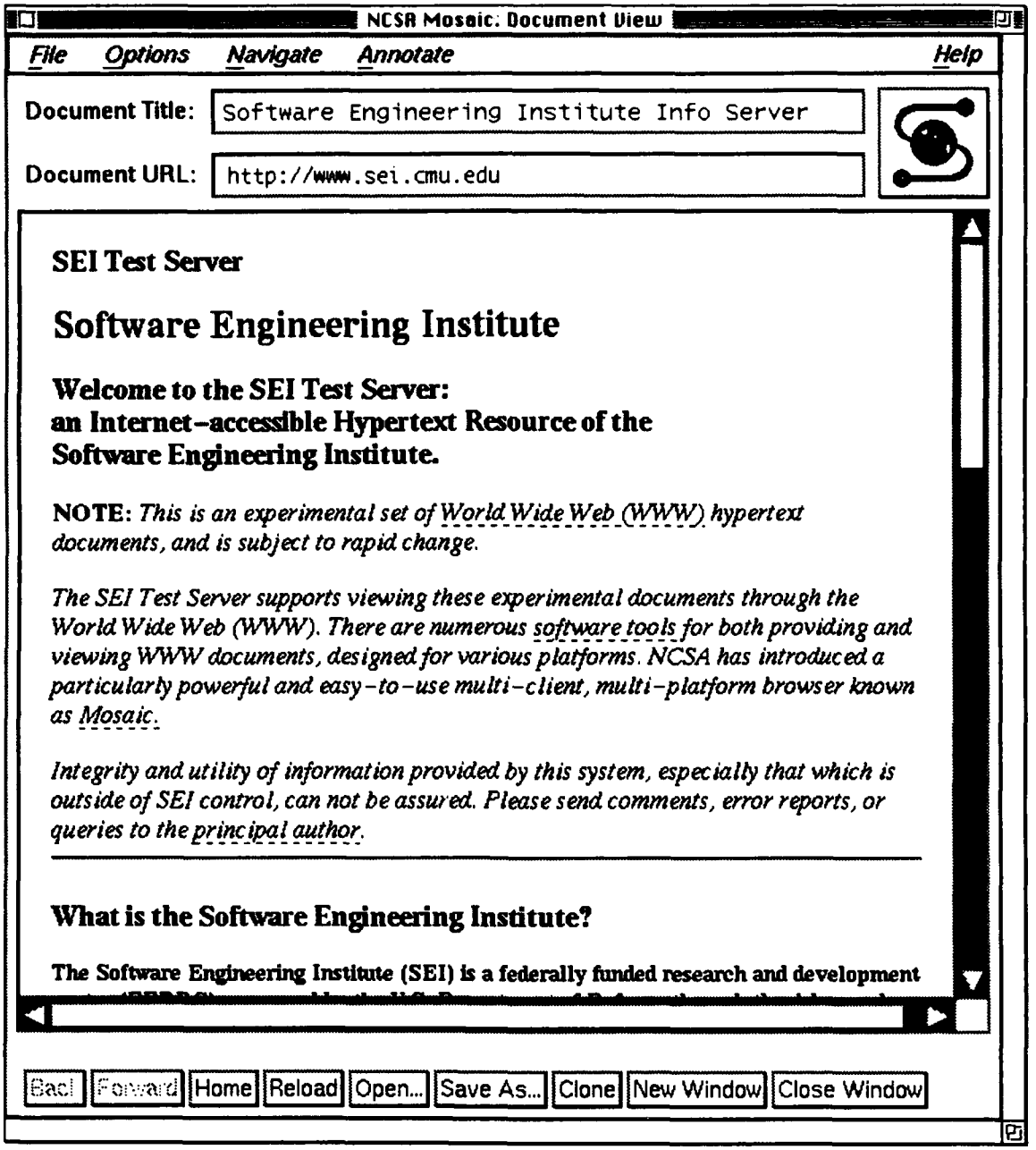

Figure 4: Home Page

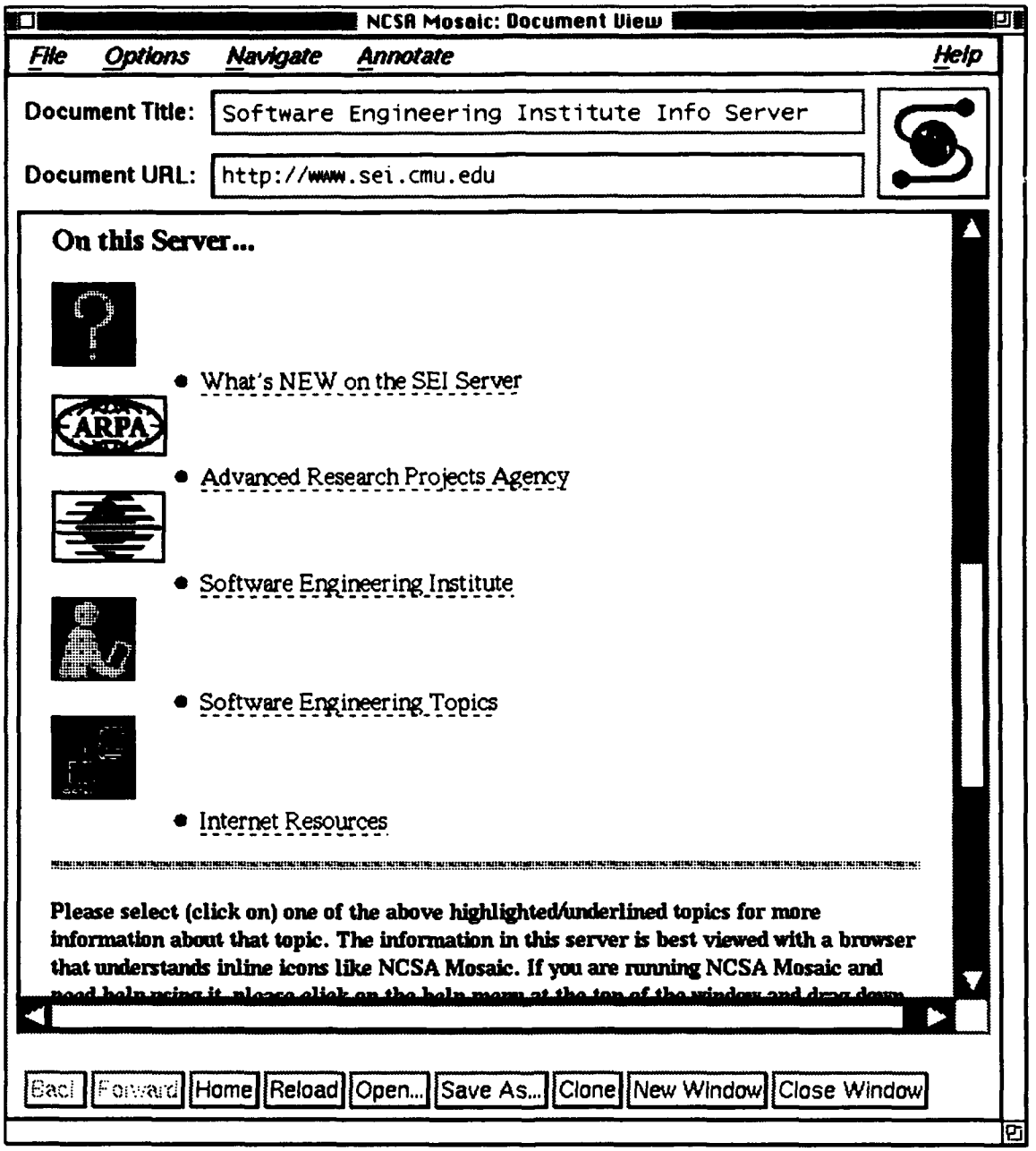

Figure 5: Initial Set of Choices

5.3.2 ARPA SISTO Software Efforts

Having selected "Advanced Research Projects Agency" from the set of choices shown in Figure 5, a page describing the ARPA SISTO efforts is retrieved from the server and displayed by the WWW client software. Figure 6 shows the software engineering portion of this page. Each of the underlined items is a hypertext link to additional information.

In the following examples, portions of the pilot system dealing with software engineering environments and the Software Engineering Institute will be explored.

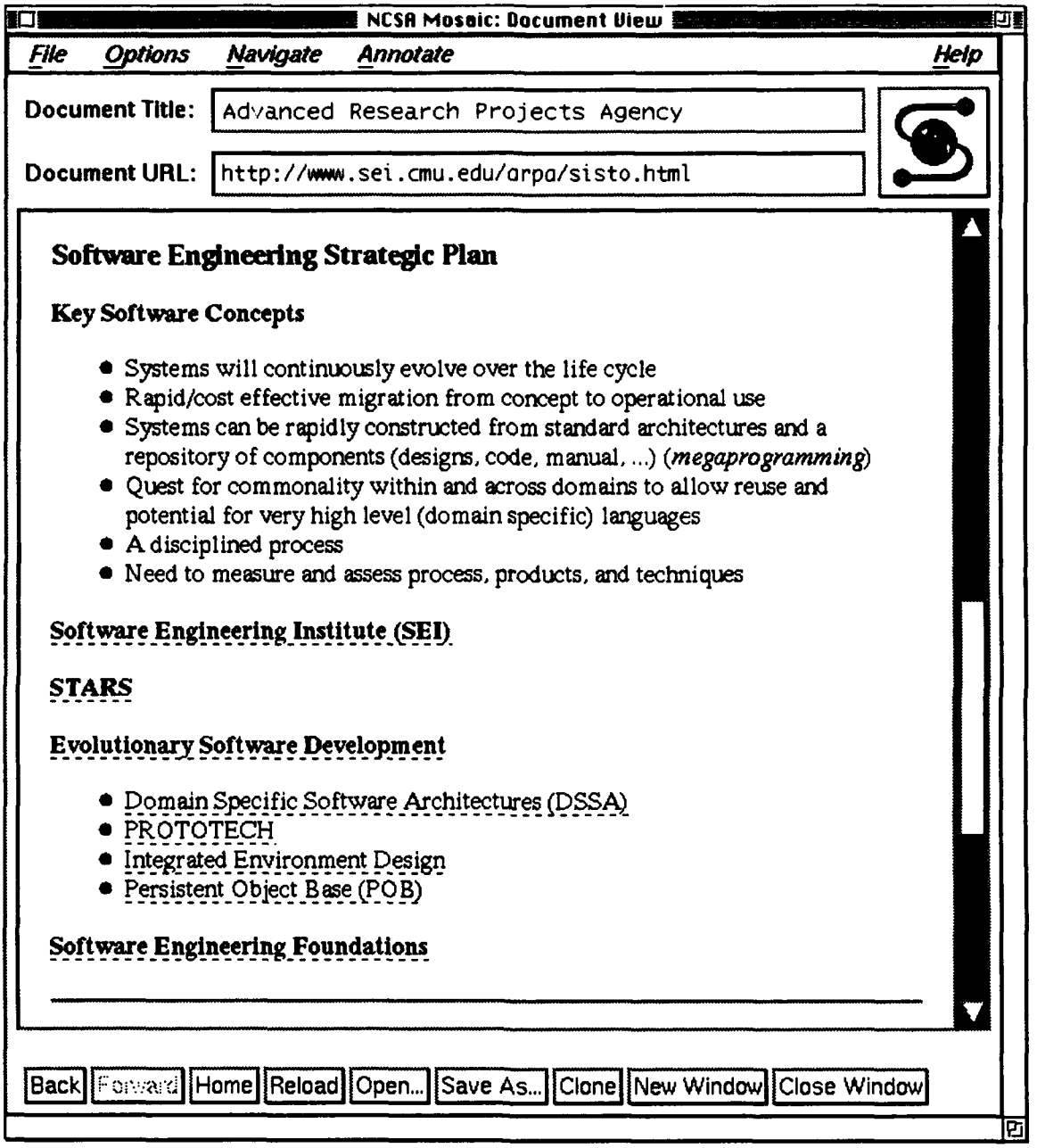

Figure 6: ARPA Software Engineering Strategic Plan

As software engineering environments was the focus of the pilot effort, selecting the "Integrated Environment Design" item leads the user to information about the ongoing software engineering environment efforts sponsored by SISTO. Figure 7 shows the top-level page on these environment efforts. Figures 8a, 8b, and 8c show further information about the Arcadia Project. That page (which the user can scroll through) is layered beneath the top-level description of the software engineering environment efforts shown in Figure 7 and can be accessed by selecting the first link on that page.

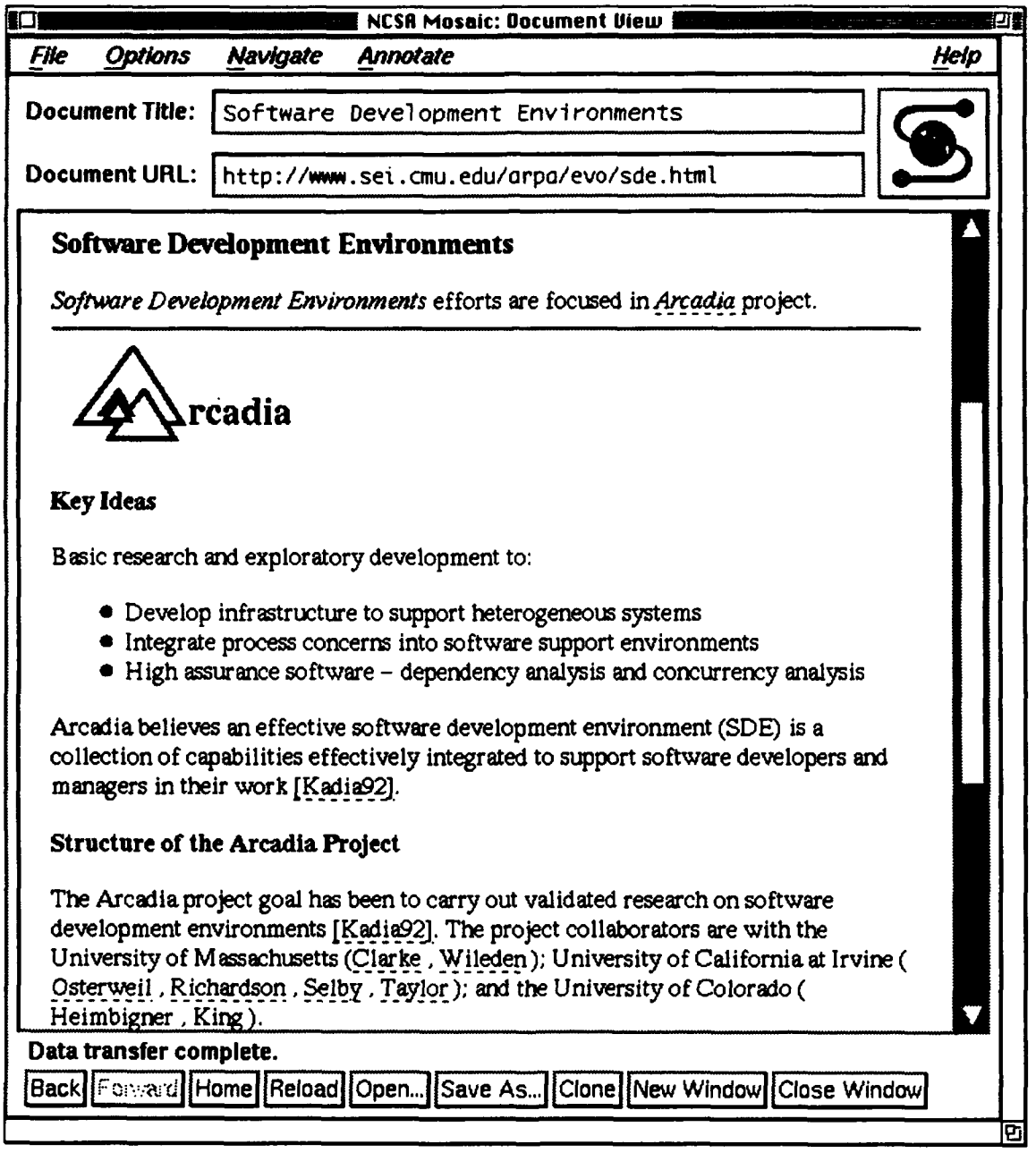

Figure 7: Software Engineering Environments

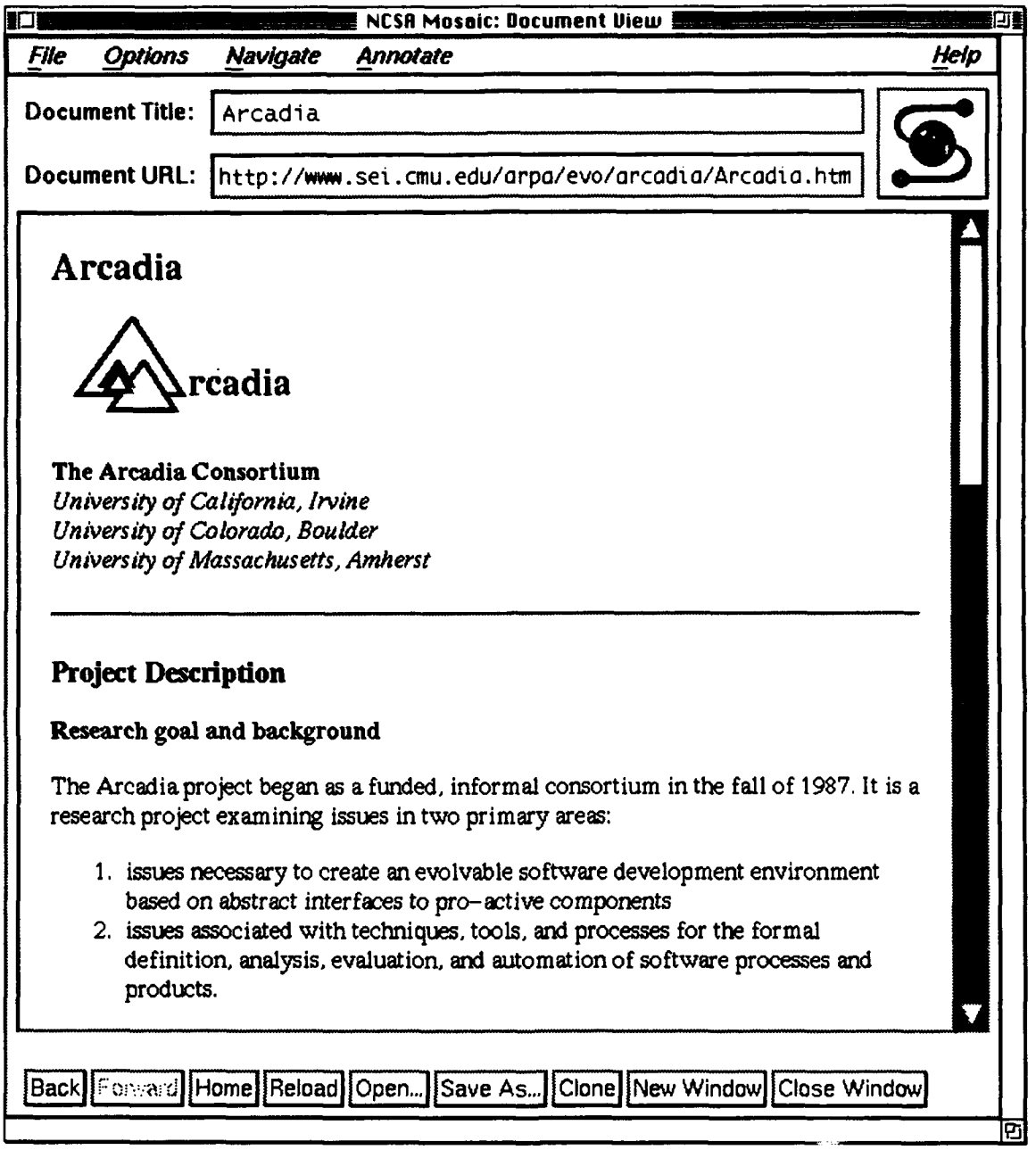

Figure 8a: The Arcadia Project

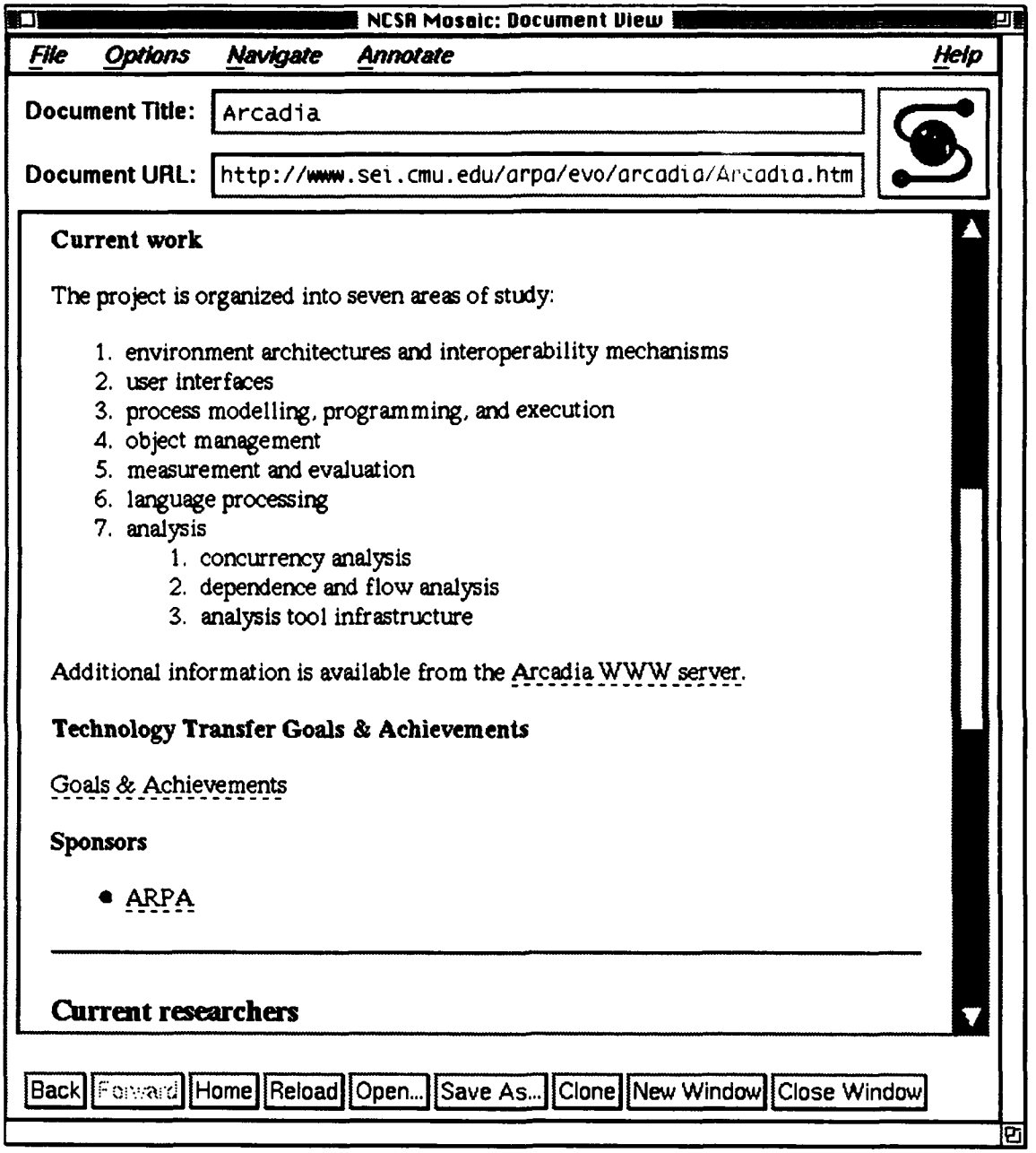

Figure 8b: The Arcadia Project

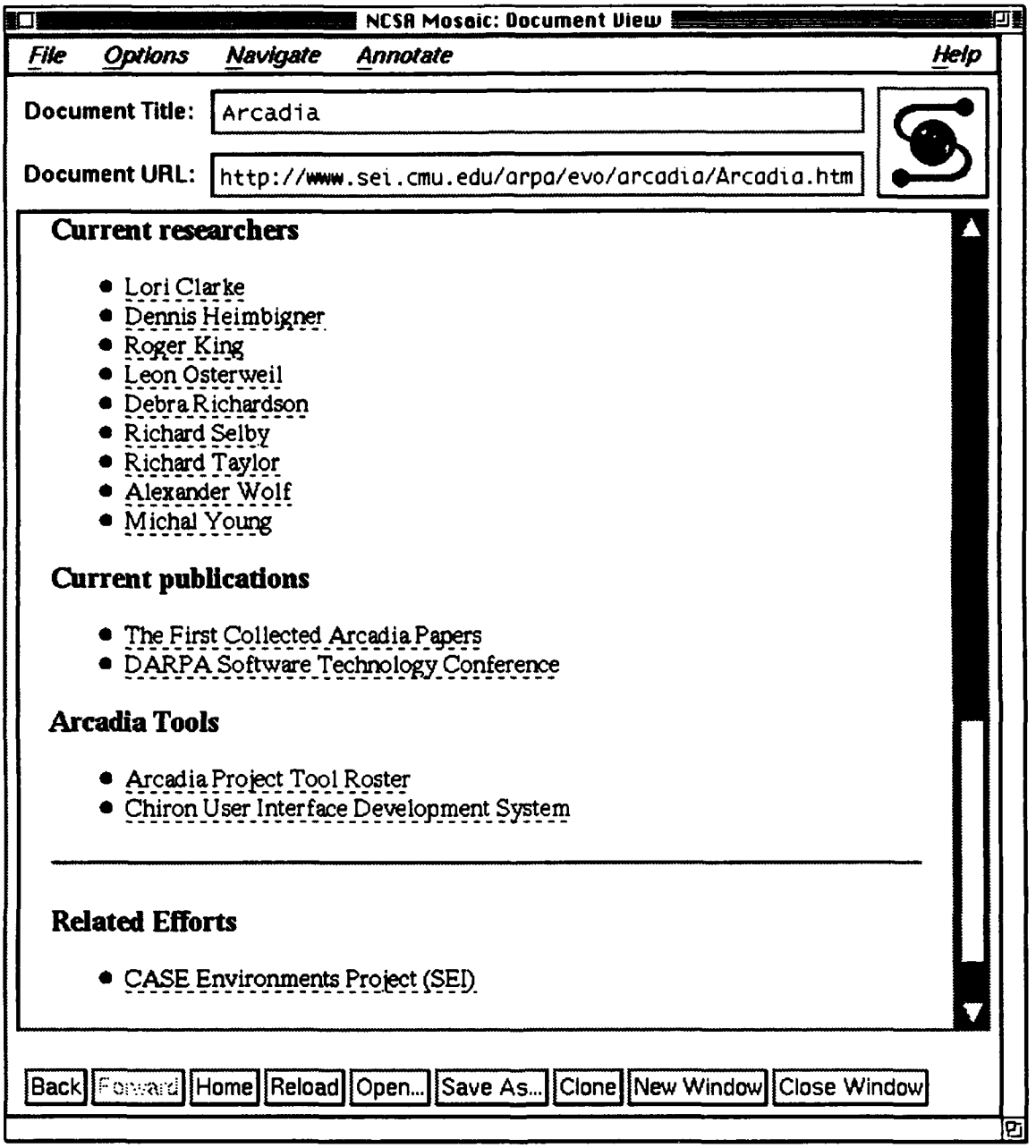

Figure 8c: The Arcadia Project

Figure 8c shows a link to related efforts. Traversing this hypertext link takes the user to a description of the SEI CASE Environments Project, a portion of which is shown in Figure 9.

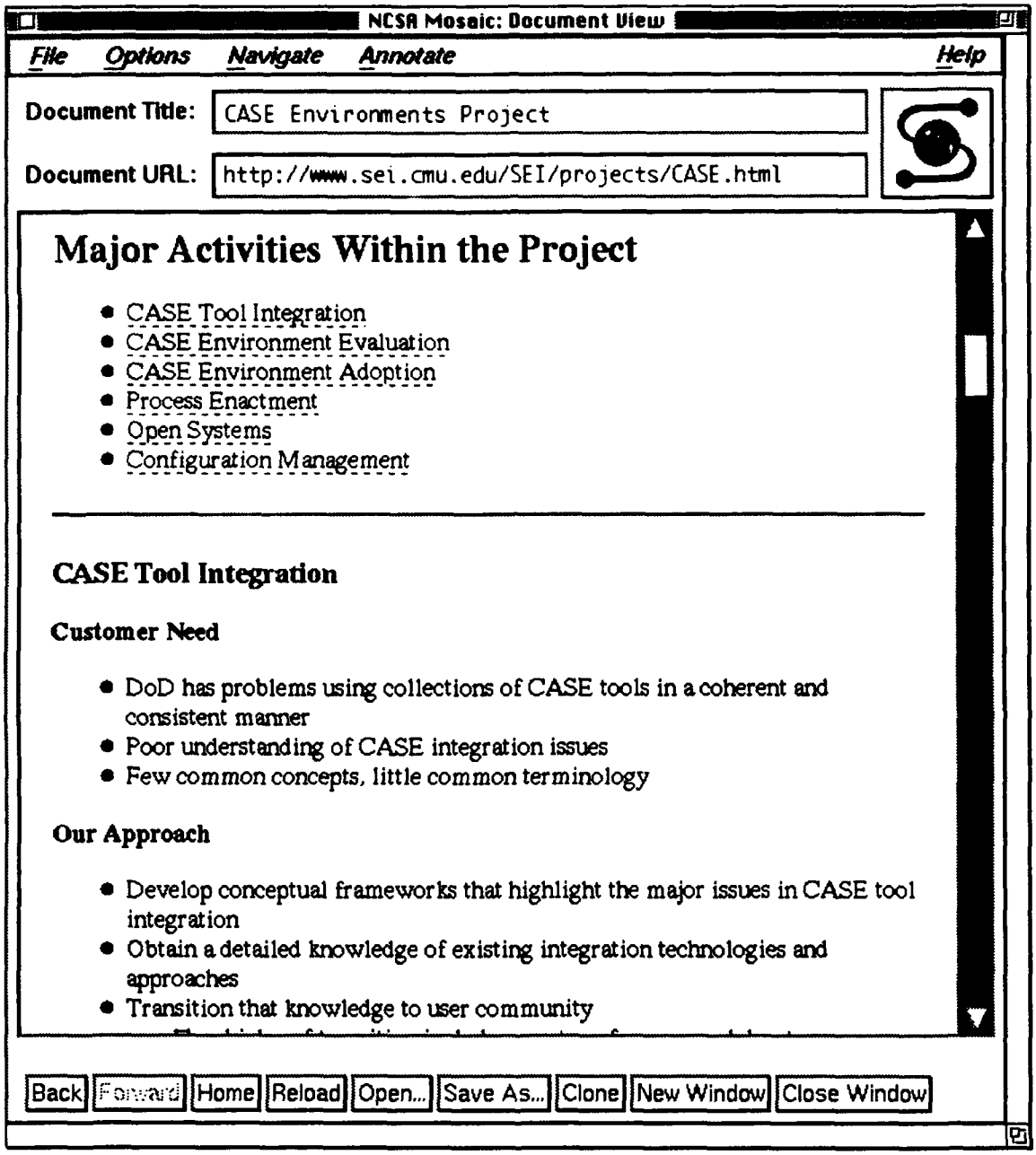

Figure 9: SEI CASE Environments Project

5.3.3 Software Engineering Institute

The description of the SEI CASE Environments Project is one form of information that is contained within the pilot system about the SEI. Other information about the SEI can be accessed through the SEI home page, shown in Figure 10. This home page can be easily accessed from the initial set of choices (Figure 5) or from the ARPA page (Figure 6).

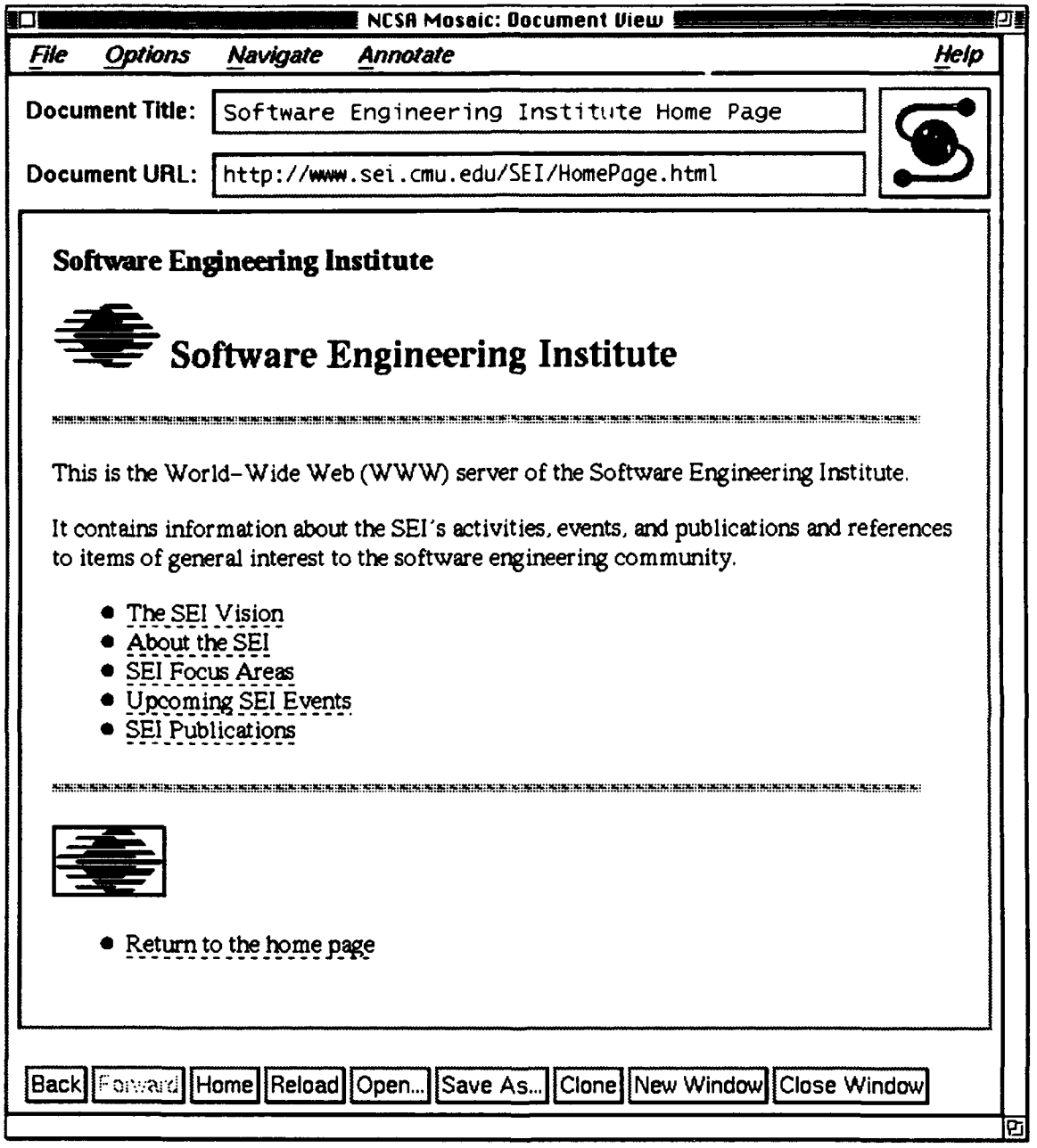

Figure 10: SEI Home Page

From the SEI home page (Figure 10), the user has an option within the item "SEI Publications" to search the annotated catalog of SEI publications. Figure 11 shows the results of a search of this annotated catalog for items containing the term "environments".

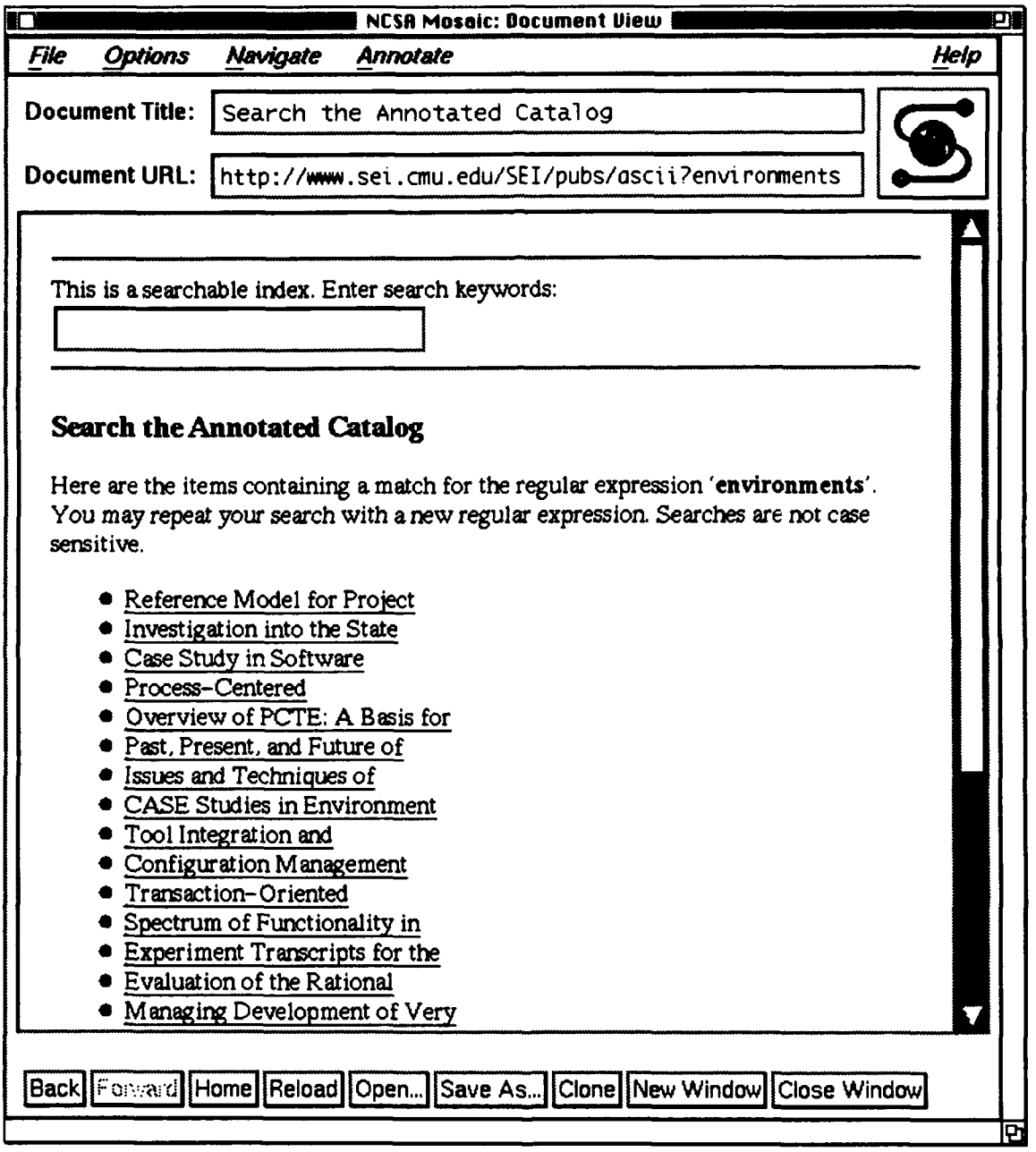

Figure 11: Results of a Search of the Annotated Catalog for the Term "environments"

5.3.4 Software Engineering Topics

To allow access to a variety of network-accessible information without having to navigate through an institutionally focused hierarchy, a page of software engineering topics was prepared as the pilot system evolved. This page is accessible from the home page shown in Figure 5. As information about projects (Section 4.2.2) or resources was identified, pointers to that information were added to an expanding set of topically oriented information pages. Figure 12 depicts this list of topics as the user sees it. Figures 13a and 13b show the Software Engineering Environments topic page from the pilot system.

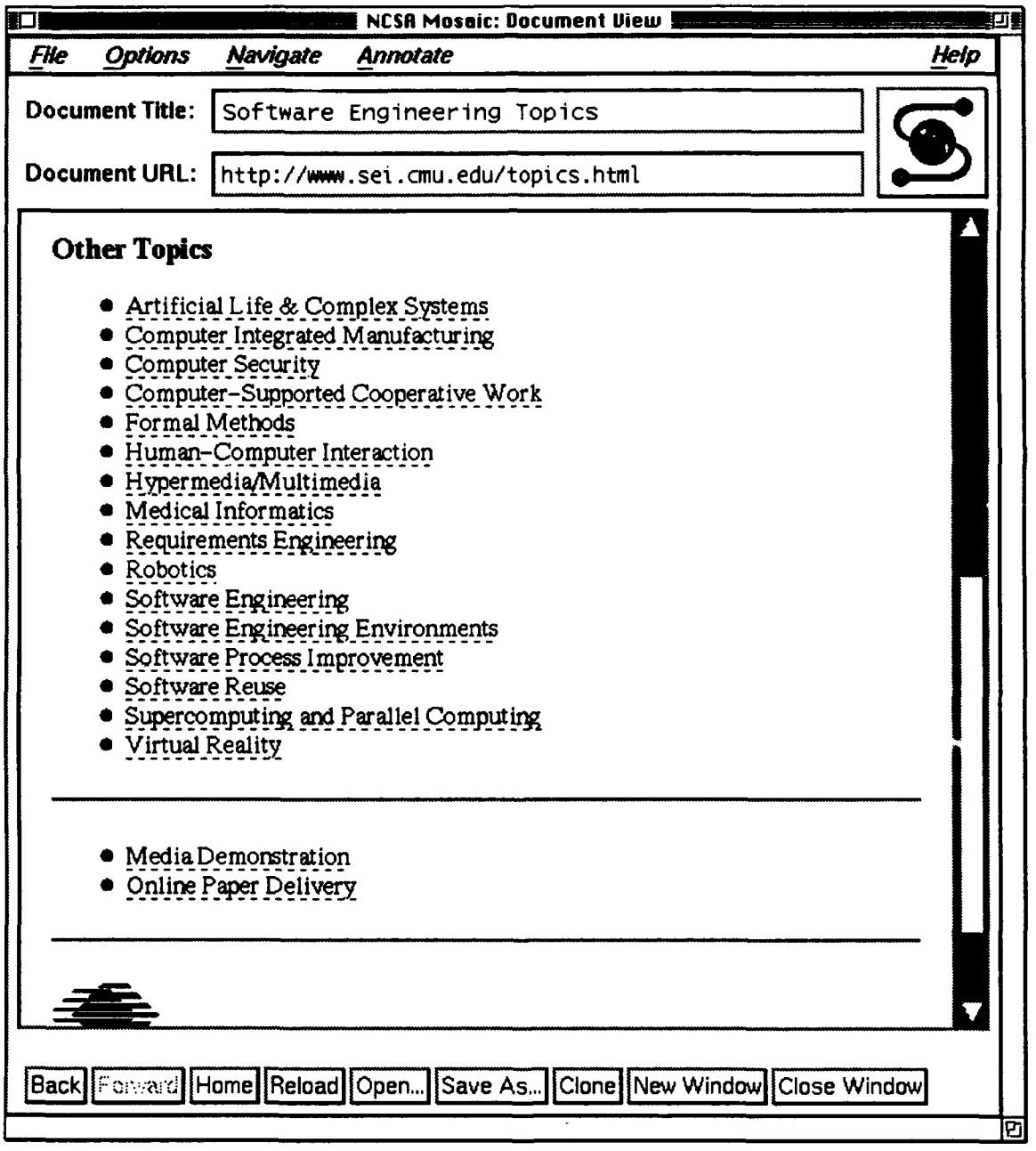

Figure 12: Software Engineering Topics

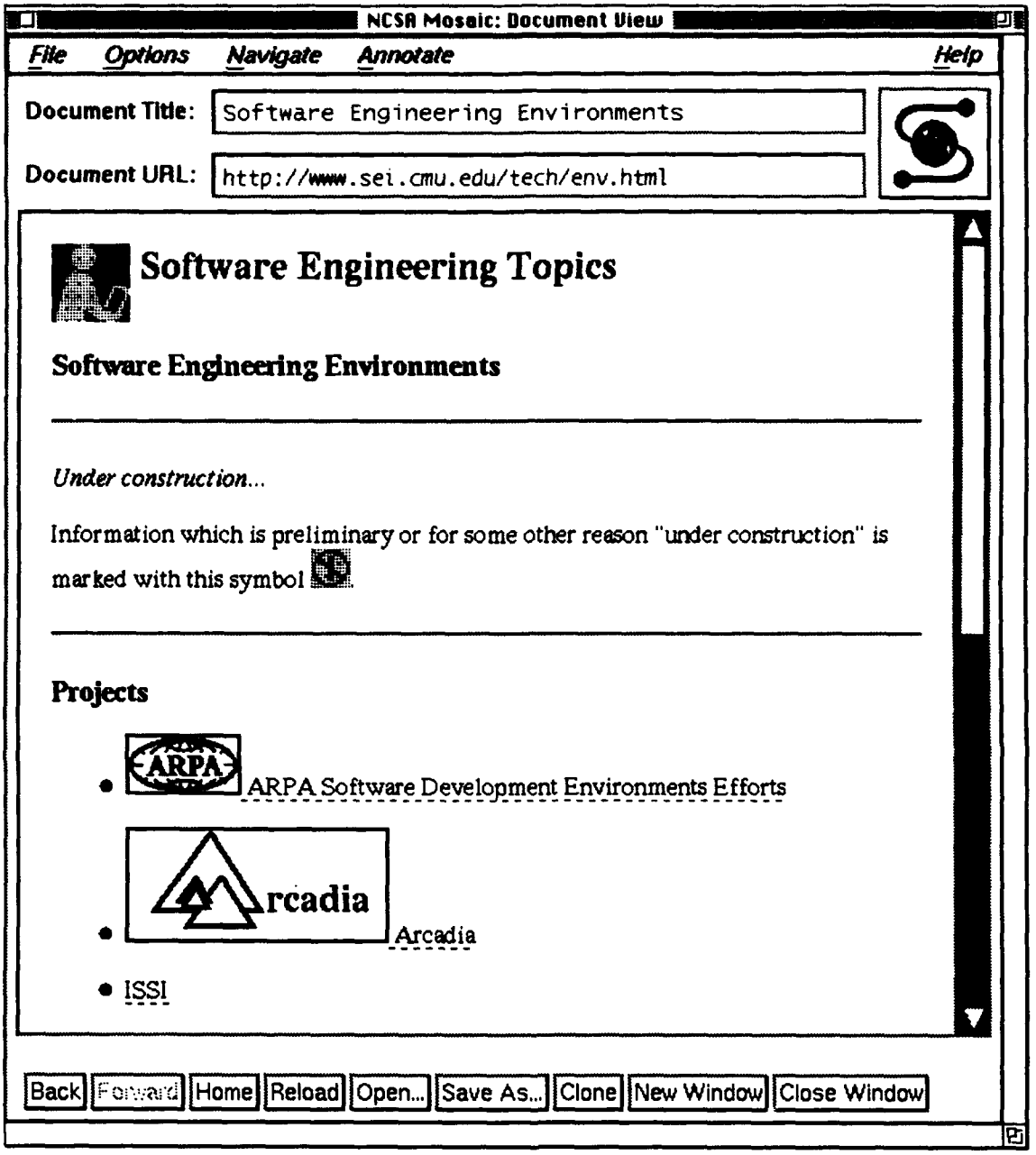

Figure 13a: Topic Page for Software Engineering Environments

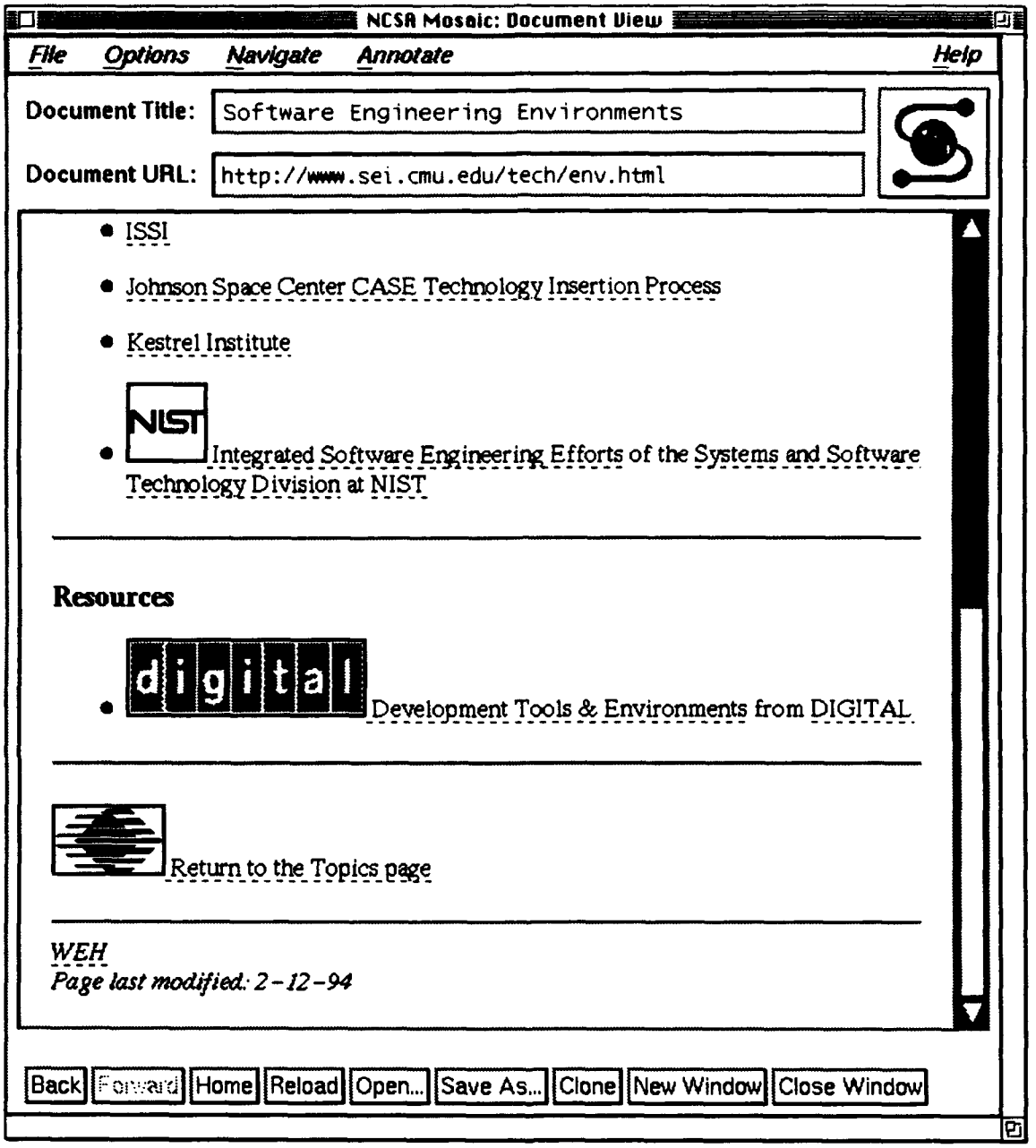

Figure 13b: Topic Page for Software Engineering Environments

6 Lessons Learned

This section analyzes the pilot efforts, process, information content, and feedback from the various demonstrations to derive lessons learned and to recommend necessary process changes for future phases of this effort. The purpose of this analysis is to factor in lessons learned, yielding a more effective process as the effort is expanded and automation is increased.

6.1 WWW Technology

The pilot effort has demonstrated the use of WWW technologies for the information base application. These technologies are sufficiently available and robust enough to support deployment of this type of application using the technologies. NCSA Mosaic is but one of several WWW clients, and it is supported on three key platforms—X Window System, Macintosh, and Microsoft Windows.

Several servers also exist. They have each gone through several releases, adding functionality and capabilities. These servers are currently being used by sites to support thousands of accesses per day.

6.2 Information Content, Structure, and Access

Although a limited content area was used for the pilot system, several lessons emerged from this effort that deal with the conversion of information to hypermedia, accessing information via hypertext linkages and search mechanisms, and gaining access to information content.

First among these lessons is the necessary translation of linear information to a hypertext structure. There is not always a straight translation from one format to another that will produce an optimal document in the hypertext format. Not only is the presentation different on the screen from the printed page, but the capabilities for cross-referencing and linking are also different in the hypertext medium.

Some people think that a document in hypertext should be designed and written with hypertext in mind, but this does not prevent the translation of existing documents into a hypermedia form. Three sizable segments of the demonstration system were converted from existing briefings with the addition of appropriate hypertext linkages. Adding these linkages is time-consuming and requires considering the potential use of the material by the reader (i.e., document design). Both references to other locations in the same or related documents are useful; however, a benefit of having an Internet-accessible WWW server is that links within the information may point to other information sources. An example of this is seen in Figure 8b, which points to the Arcadia Project's WWW server.

Accessing information via hypertext linkages is one means of locating information in the Web, but other search mechanisms can also be useful. Search mechanisms, such as full-text searches or WAIS searches, can provide the user with searchable indexes of the collected material. Such indices can serve as a thesaurus to aid the user in quickly finding appropriate information. Other structuring mechanisms [Rivlin 94] can also be useful to aid the user.

Minimal search capabilities were available in the pilot system. These primarily provided working demonstrations of search mechanisms that were possible using the WWW technology. Feedback from use of the pilot system indicated that users desired a greater number of search options than were provided in the pilot system. This user behavior is confirmed by other studies of online information [Girill 88, Brown 92].

Gaining access to information content is an important part of building the information base. For the most part, the information content of the pilot system was drawn from existing sources: publicly released written documents, existing briefings, and existing information repositories, such as archives of technical reports or archives of CERT advisories. The information content that was developed specifically for the pilot was the structuring and presentation of that material into a hypermedia information structure. Having access to this existing information, and updates to this information, is key to maintaining a usable information service.

As many projects do not plan their technology transition efforts in parallel with the planning of their technology maturation efforts, information describing planned technology transfer efforts may not be as accessible as information describing projects. Without having existing sources of this information available, it may be difficult to populate the technology transfer goals and achievements information structure for each project.

The distribution limitations placed on sources of information are a related aspect of gaining access to information content. Information relating to the sponsoring organization component of the information model (Section 4.2.5) is limited in its distribution by one government agency, and may not be available for wide distribution. These sorts of limitations (preventing dissemination of information like "who is working on or responsible for a project") cannot help speed the transition of knowledge and information about evolving technologies.

6.3 Defining a Development Process

The pilot effort developed a demonstrable, repeatable process for populating the information base. Multiple content developers were able, within the pilot period, to gain proficiency at converting existing textual documents to a hypermedia format. This allowed the development of information about the SEI, a selected ARPA SISTO project (Arcadia), and the CERT as a proof of concept of using the information base concepts.

As with other forms of multimedia product development (designing a print product, producing a movie, etc.), a variety of skills may be needed to contribute to the successful end result. These skills may need to be fostered in one individual or may be drawn from a team. They include skills in writing, document design, graphics design, content expertise, usability engineering, and software development.

A wealth of information is available through WWW to document the protocols, describe the software programs and their capabilities, and give guidance on how to encode documents for presentation using WWW technologies. Numerous tools to aid content developers are emerging, such as editors, translators, and sample programs. However, developing useful and usable WWW information services requires more than just access to and knowledge about tools.

What is not yet available is a usable handbook for developing information services using the WWW. A single practical guidebook is needed that describes what goes into and how to perform the processes of designing, writing, and producing hypermedia documents for the Web.[6] Such a guidebook, written for non-experts, should cover topics such as:

- guidelines for writers
- how to design hypermedia documents (of various types)
- introduction to Hypertext Markup Language (HTML)
- *HTML Reference Guide* and coding examples
- how to identify appropriate hypertext links
- descriptions of the various technologies (or services such as FTP, WAIS, mailing list archives, information search engines) available through WWW and how to incorporate them in designing an information structure
- designing and using interactive forms
- usability testing and evaluation for hypermedia applications
- identification of useful repositories (of icons, sample programs, tools, etc.)

6. *The HTML Reference Guide* [Deuel 93] is a well-written, useful introduction to the Hypertext Markup Language, but it addresses only this single topic.

7 Follow-On Plan

A plan for proceeding beyond the pilot effort has been proposed. A key component of that plan is to continue expanding the content of the pilot information base, driven in part by actual use of the evolving system by ARPA program managers, SEI staff, and others. During this phase, we will continue with the collection, categorization, and storage of the information related to SISTO-sponsored research. Future phases will expand the pilot information base to an operational system.

The mechanisms established for the management of SISTO-related information will be used to capture similar information from SEI principals involved in various technology areas. This state-of-the-art and state-of-the-practice information will then be added to the evolving information base.

Issues that should be addressed during this follow-on period include:

- scope of the technical areas to be covered by the evolving information base
- access to the evolving information base
- installation and support of the selected support tools
- implementation and support plans
- monitoring and evaluation of the metrics data gathered

Based on use of the evolving information base, lessons learned, and metrics gathered, follow-on tasks will explore alternative uses, media, and mechanisms for the evolving information base. For example, in addition to the obvious information storage and dissemination uses of this information base, there are other potential future uses of this evolving information base. One such use could be to serve as a testbed for integration with other information technologies, such as intelligent agents for selective dissemination of information (SDI) or user modeling techniques. Another use is as a technology transfer testbed enabling collaboration with other groups as a means of exploring further use of the technologies.

Candidate measures of utility for the publicly available information base should be defined in terms of usefulness and usability. If people are able to effectively use the information base, if it provides needed information, and if they are able to use it in sufficiently large numbers (i.e., greater than 500 accesses per day), then the operational information base could be considered a success. It is these goals that the follow-on efforts will seek to achieve.

Acknowledgments

This pilot effort could not have been possible in the given time frame without the assistance of many other individuals. John Salasin (ARPA), Teiro Cuccinelli (DynCorp Meridian), Barbara White, Lizann Stelmach, Janice Marchok, John Leary, and Alan Brown (SEI) assisted in obtaining content information for use in populating the pilot system. Kristine Nichols and Tom Longstaff (CERT) provided valuable insights as we collaborated on their proof-of-concept study for a hypertext Frequently Asked Questions document. Gran Goza and Chas DiFatta supported establishing this service within the SEI computing framework. David Pekular, Larry Crowe, and Ken Stupak of the SEI provided timely support for several demonstrations, and their help was greatly appreciated. Numerous other individuals provided useful feedback as the demonstration capabilities of the pilot improved. For their comments and feedback, I am also grateful.

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Appendix A Sample HTML Templates

This appendix contains sample Hypertext Markup Language (HTML) templates for each of the information structures proposed in Section 4.

A.1 Technology Area (Area of Interest)

```
<HTML>
<!-- $id:$ -->
<HEAD>
<TITLE>Name of Area of Interest</TITLE>
</HEAD>

<BODY>
<H1>Name of Area of Interest</H1>

<!-- Insert first paragraph of descriptive text below -->

<P>
<!-- Repeat as many times as needed for additional
paragraphs -->
<!-- of descriptive text -->

<!-- Be sure to conclude each paragraph with a paragraph
tag -->
<P>

<HR>
<H2>Projects</H2>

<!-- Insert links to relevant project profiles here -->
<UL>
<!-- Repeat List Item (LI to /LI) as needed for each project
-->
<LI>
<A HREF="">Project Name</A>
</LI>
</UL>

<HR>
<H2>Resources</H2>

<!-- Insert links to relevant resources here -->
<!-- Resources can include WWW servers, ftp servers, -->
<!-- gopher sites, etc. -->
<UL>
<!-- Repeat List Item (LI to /LI) as needed for each
resource -->
<LI>
<A HREF="">Resource Name</A>
</LI>
</UL>
```

```
<P>
<HR>
<!-- Insert author's links and last-update information
below -->
<!%%Author><ADDRESS><A HREF=
"/tmp/webmaster.html">WEH</A></ADDRESS><!%%EndAuthor>
<!%%DateLastModified><ADDRESS> Page last modified: 12-13-
93 </ADDRESS><!%%EndDateLastModified>

</BODY>
</HTML>
```

A.2 Organization

```
<HTML>
<!-- $id:$ -->
<HEAD>
<TITLE>Organization Name</TITLE>
</HEAD>

<BODY>
<H1>
<!-- Insert OPTIONAL logo below -->
<IMG align=bottom SRC="/icons/sei.gif">
<!-- Insert organization name below -->
Organization Name
</H1>

<HR>
<!-- Insert first paragraph of descriptive text below -->

<P>
<!-- Repeat as many times as needed for additional
paragraphs -->
<!-- of descriptive text -->

<!-- Be sure to conclude each paragraph with a paragraph
tag -->
<P>

<H2>Projects</H2>

<!-- Insert links to the organization's project profiles
here -->
<UL>
<!-- Repeat List Item (LI to /LI) as needed for each project
-->
<LI>
<A HREF="">Project Name</A>
</LI>
</UL>

<HR>
```

```
<H2>Resources</H2>

<!-- Insert links to relevant resources here -->
<!-- Resources can include WWW servers, ftp servers, -->
<!-- gopher sites, etc. -->
<UL>
<!-- Repeat List Item (LI to /LI) as needed for each
resource -->
<LI>
<A HREF="">Resource Name</A>
</LI>
</UL>

<P>
<HR>
<H2>Contact information:</H2>
<ADDRESS>Name</ADDRESS>
<ADDRESS>Address Line 1</ADDRESS>
<ADDRESS>More Address</ADDRESS>
<ADDRESS>More Address</ADDRESS>
<ADDRESS>More Address</ADDRESS>
<ADDRESS>City, State, ZIP (Postal) Code, Country</ADDRESS>
<B>E-mail: </B><ADDRESS>user@host.domain</ADDRESS>
<B>Phone: </B><ADDRESS>+cc (ac) phn-nums</ADDRESS>

<P>
<HR>
<!-- Insert author's links and last-update information
below -->
<!%%Author><ADDRESS><A HREF=
"/tmp/webmaster.html">WEH</A></ADDRESS><!%%EndAuthor>
<!%%DateLastModified><ADDRESS> Page last modified: 12-13-
93</ADDRESS><!%%EndDateLastModified>

</BODY>
</HTML>
```

A.3 Project

```
<HTML>
<!-- $id:$ -->
<HEAD>
<TITLE>Project Name</TITLE>
</HEAD>

<BODY>
<H1>Project Name</H1>

<!-- Insert OPTIONAL organization name below -->
<P>
<ADDRESS>Organization</ADDRESS>
<P>
<HR>
```

```
<H2>Project Description</H2>

<H3>Research goal and background</H3>

<!-- Insert first paragraph of descriptive text below -->

<P>
<!-- Repeat as many times as needed for additional
paragraphs -->
<!-- of descriptive text -->

<!-- Be sure to conclude each paragraph with a paragraph
tag -->
<P>

<H3>Current work</H3>

<!-- Insert first paragraph of descriptive text below -->

<P>
<!-- Repeat as many times as needed for additional
paragraphs -->
<!-- of descriptive text -->

<!-- Be sure to conclude each paragraph with a paragraph
tag -->
<P>

<H3>Technology Transfer Goals & Achievements</H3>
<!-- Link to the appropriate technology transfer info (if
available) -->
<A HREF="">Goals & Achievements</A>

<H3>Sponsors</H3>
<!-- Insert pointers to HTML with information about the -->
<!-- project sponsors, such as Work Unit Package data -->
<!-- NOTE: This link may not be active on all systems or -->
<!-- it may lead to just a subset of the Work Unit -->
<!-- Package data (i.e., this is a collection of -->
<!-- data that may have restrictions on viewing.) -->
<!-- -->
<!-- Can Break into categories, if desired - just repeat -
->
<!-- the lists with a heading between -->
<UL>
<!-- Repeat List Item (LI to /LI) as needed for each sponsor
-->
<LI>
<A HREF="project-name_work_unit_package.html">Sponsor's
Name</A>
</LI>
</UL>

<HR>
```

```
<H2>Current researchers</H2>
<!-- Insert links to researchers -->
<!-- Can Break into categories, if desired - just repeat -
->
<!-- the lists with a heading between -->
<UL>
<!-- Repeat List Item (LI to /LI) for each researcher -->
<LI>
<A HREF="">Researcher's Name</A>
</LI>
</UL>

<H2>Current publications</H2>

<!-- Insert links to publications -->
<!-- Can Break into categories, if desired - just repeat -
->
<!-- the lists with a heading between -->
<UL>
<!-- Repeat List Item (LI to /LI) as needed -->
<!-- for each publication. -->
<!-- Use standard citation formats -->
<LI>
Author(s). <A HREF="">Publication Title</A>. Where
published, etc.
</LI>
</UL>
<HR>
<H2>Related Efforts</H2>

<!-- Insert links to relevant project profiles here -->
<UL>
<!-- Repeat List Item (LI to /LI) as needed for each project
-->
<LI>
<A HREF="">Project Name</A>
</LI>
</UL>
<P>
<HR>
<!-- Insert author's links and last-update information
below -->
<!%%Author><ADDRESS><A HREF=
"/tmp/webmaster.html">WEH</A></ADDRESS><!%%EndAuthor>
<!%%DateLastModified><ADDRESS> Page last modified: 12-13-
93</ADDRESS><!%%EndDateLastModified>

</BODY>
</HTML>
```

A.4 Technology Transfer

```
<HTML>
<!-- $id:$ -->
<HEAD>
<TITLE>Project Name</TITLE>
</HEAD>

<BODY>
<H1>Project Name</H1>

<H2>Technology Transfer Goals & Achievements</H2>

<HR>

<H3>Users/recipients</H3>
<!-- Intended (or actual) users or recipients of the
technology -->
<!-- Insert first paragraph of descriptive text below -->

<P>
<!-- Repeat as many times as needed for additional
paragraphs -->
<!-- of descriptive text -->

<!-- Be sure to conclude each paragraph with a paragraph
tag -->
<P>

<H3>Maturity</H3>
<!-- Measure of the maturity of the technology -->
<!-- Insert first paragraph of descriptive text below -->

<P>
<!-- Repeat as many times as needed for additional
paragraphs -->
<!-- of descriptive text -->

<!-- Be sure to conclude each paragraph with a paragraph
tag -->
<P>

<H3>Availability</H3>
<!-- Time frame(s) for availability of this technology -->
<!-- (at various stages of maturation) -->
<!-- Insert first paragraph of descriptive text below -->

<P>
<!-- Repeat as many times as needed for additional
paragraphs -->
<!-- of descriptive text -->

<!-- Be sure to conclude each paragraph with a paragraph
tag -->
```

```
<P>

<H3>Value/Benefit</H3>
<!-- Anticipated (actual) value or benefits to
user/recipient -->
<!-- Insert first paragraph of descriptive text below -->

<P>
<!-- Repeat as many times as needed for additional
paragraphs -->
<!-- of descriptive text -->

<!-- Be sure to conclude each paragraph with a paragraph
tag -->
<P>

<H3>Technology Adoption Considerations</H3>
<!-- Prerequisites for adoption, resources required for
adoption -->
<!-- Insert first paragraph of descriptive text below -->

<P>
<!-- Repeat as many times as needed for additional
paragraphs -->
<!-- of descriptive text -->

<!-- Be sure to conclude each paragraph with a paragraph
tag -->
<P>

<HR>

<H2>Contact information:</H2>
<ADDRESS>Name</ADDRESS>
<ADDRESS>Address Line 1</ADDRESS>
<ADDRESS>More Address</ADDRESS>
<ADDRESS>More Address</ADDRESS>
<ADDRESS>More Address</ADDRESS>
<ADDRESS>City, State, ZIP (Postal) Code, Country</ADDRESS>
<B>E-mail: </B><ADDRESS>user@host.domain</ADDRESS>
<B>Phone: </B><ADDRESS>+cc (ac) phn-nums</ADDRESS>

<P>
<HR>
<!-- Insert author's links and last-update information
below -->
<!%%Author><ADDRESS><A HREF=
"/tmp/webmaster.html">WEH</A></ADDRESS><!%%EndAuthor>
<!%%DateLastModified><ADDRESS> Page last modified: 12-13-
93</ADDRESS><!%%EndDateLastModified>

</BODY>
</HTML>
```

A.5 Sponsoring Organization

```
<HTML>
<!-- $id:$ -->
<HEAD>
<TITLE>Sponsor's Name</TITLE>
</HEAD>

<BODY>
<H1>Sponsor's Name</H1>

<!-- Repeat as many times as needed for additional projects
-->
<H2>Project Title: </H2>

<HR>
<H2>RESPONSIBLE ORGANIZATION</H2>
<B>NAME: </B>
<BR><B>COMPONENT: </B>
<BR><DL><DT><B>ADDRESS: </B>
<!-- Insert address below -->
<!-- Insert as many lines as needed -->
<DD>
</DL>

<H3>RESP. INDIVIDUAL:</H3>
<!-- Insert name below -->

<BR><B>OFFICE SYMBOL/MAIL STOP: </B>
<BR><B>TEL NO:</B> CC (AC) XXX-XXXX
<BR><B>E-Mail:</B> user@host.domain

<HR>
<H2>PERFORMING ORGANIZATION</H2>
<B>NAME: </B>
<BR><B>COMPONENT: </B>
<BR><DL><DT><B>ADDRESS: </B>
<!-- Insert address below -->
<!-- Insert as many lines as needed -->
<DD>
</DL>
<P>

<H3>INVESTIGATORS:</H3>
<B>PRINCIPAL INVESTIGATOR: </B>
<P><B>OFFICE SYMBOL/MAIL STOP: </B>
<BR><B>TEL NO:</B> CC (AC) XXX-XXXX
<BR><B>E-Mail:</B> user@host.domain

<!-- Repeat as many times as needed for additional staff -
->
<P>
<B>ASSOCIATE INVESTIGATOR: </B>
<BR><B>OFFICE SYMBOL/MAIL STOP: </B>
```

```
<BR><B>TEL NO: </B>CC (AC) XXX-XXXX
<BR><B>E-Mail:</B> user@host.domain

<HR>
<H2>CONTRACT/GRANT INFORMATION</H2>
<B>Contract/Grant: </B>
<BR><B>Effective Date: </B>
<BR><B>Expiration Date: </B>
<BR><B>Contract Face Value (in K$): </B>
<BR><B>Contract Cumulative to Date (in K$): </B>

<HR>
<H2>KEYWORDS</H2>
<!-- Insert list of descriptors below -->
<!-- Note that keywords and descriptors could be linked -->
<!-- to other areas of interest or used as index terms -->

<H2>DESCRIPTORS</H2>
<!-- Insert list of descriptors below -->


<H2>OBJECTIVES</H2>
<!-- Insert first paragraph of descriptive text below -->

<P>
<!-- Repeat as many times as needed for additional
paragraphs -->
<!-- of descriptive text -->

<!-- Be sure to conclude each paragraph with a paragraph
tag -->
<P>

<H2>APPROACH: </H2>
<!-- Insert first paragraph of descriptive text below -->

<P>
<!-- Repeat as many times as needed for additional
paragraphs -->
<!-- of descriptiv    t -->

<!-- Be sure to conclude each paragraph with a paragraph
tag -->
<P>

<H2>PROGRESS: </H2>
<B>START DATE:</B>
<BR><B>END DATE:</B>
<BR><!-- Insert first paragraph of descriptive text below
-->

<P>
<!-- Repeat as many times as needed for additional
paragraphs -->
```

```
<!-- of descriptive text -->

<!-- Be sure to conclude each paragraph with a paragraph
tag -->
<P>

<B>PRODUCTS: </B>
<OL>
<LI>
<B>TITLE: </B> <A HREF=where-this-pub-is.for-
real>Publication</A>
<BR><B>Report Number: </B>
<BR><B>NTIS/DTIC Accession Number:</B>
</LI>
</OL>

<P>
<HR>
<!-- Insert author's links and last-update information
below -->
<!%%Author><ADDRESS><A href=
"/tmp/webmaster.html">WEH</A></ADDRESS><!%%EndAuthor>
<!%%DateLastModified><ADDRESS> Page last modified: 12-15-
93</ADDRESS><!%%EndDateLastModified>

</BODY>
</HTML>
```

A.6 Researcher

```
<HTML>
<HEAD>
<TITLE>Name</TITLE>
</HEAD>

<BODY>
<H1>
<!-- Insert name below -->
Name
</H1>
<HR>

<!-- Insert optional face or photo -->
<IMG align=bottom SRC="/icons/sei.gif">

<H2>Position:</H2>
<!-- Insert position (Asst. Professor, MTS, etc.) below -->

<P>
<H2>Institution:</H2>
<!-- Insert name of the institution or organization below
-->
```

```
<P>
<H2>Degree:</H2>
<!-- Insert highest degree below -->

<P>
<H2>Research Interests:</H2>
<!-- List research interests below -->
<!-- Suggest ranking from most interested to least -->

<P>
<H2>Professional Memberships:</H2>
<!-- Insert name(s) of societies below -->

<P>
<H2>Projects:</H2>
<!-- Insert name of projects below -->

<HR>
<H2>Contact information:</H2>
<ADDRESS>Name</ADDRESS>
<ADDRESS>Address Line 1</ADDRESS>
<ADDRESS>More Address</ADDRESS>
<ADDRESS>More Address</ADDRESS>
<ADDRESS>More Address</ADDRESS>
<ADDRESS>City, State, ZIP (Postal) Code, Country</ADDRESS>
<B>E-mail: </B><ADDRESS>user@host.domain</ADDRESS>
<B>Phone: </B><ADDRESS>+cc (ac) phn-nums</ADDRESS>

<P>
<HR>
<!-- Insert author's links and last-update information
below -->
<!%%Author><ADDRESS><A href=
"/tmp/webmaster.html">WEH</A></ADDRESS><!%%EndAuthor>
<!%%DateLastModified><ADDRESS> Page last modified: 12-10-
93</ADDRESS><!%%EndDateLastModified>

</BODY>
</HTML>
```

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS None
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2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A	
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FIELD	GROUP	SUB. GR.	hypermedia information service, hypermedia, World-Wide Web (WWW), NCSA Mosaic, software engineering technology transition

19. ABSTRACT (continue on reverse if necessary and identify by block number)

This report describes the accomplishments of a pilot hypermedia information service embodying the conceptual definition of a pilot information base developed by the Software Engineering Institute (SEI) in support of the Advanced Research Projects Agency (ARPA) Software and Intelligent Systems Technology Office (SISTO). This pilot effort was conducted in support of the Technology Cost-Benefit Analysis tasks within TO&P 2-151, Software Engineering Technology Transition for Director, Defense Research and Engineering (DDR&E) and ARPA. This report also describes the intended uses and user populations of the proposed information base, design issues that influenced the struc-

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ABSTRACT — continued from page one, block 19

ture and contents of the information base, a proposed information model consisting of information content and linkages, the pilot information base including the technology selected for the initial pilot effort and the pilot capability, lessons learned from the pilot effort, and future plans relating to the information base efforts. Key to these pilot efforts was the development of a set of proposed information structures for an information base on software engineering. These hypermedia-based information structures can be presented across the Internet and displayed on local workstations using client/server technologies, such as World-Wide Web (WWW) and NCSA Mosaic (produced by the National Center for Supercomputing Applications).

This work to date has accomplished four goals. First, the objectives of the pilot effort have been met. An information base containing software engineering information that provides value to ARPA program managers has been demonstrated, and a work plan has been generated to expand from the pilot to an operational system. Second, the SEI has demonstrated a capability for effectively using the WWW, which is certain to be a critical part of the information highway for years to come. Third, techniques to enhance developers' productivity have been identified and demonstrated. Preparation of online information can be aided by templates. Delivery of online information can be enhanced through study of actual users' navigational and usage patterns. Fourth, the SEI has established a "magnetic platform" as the facilities demonstrable at the SEI can be used as a starting point for developing new technology transition capabilities.